November 2019

ConnDOT Approved Hydraulic Engineer:

STATE OF CONNECTICUT
DAVID CICIA
No. 0023439
LICENSED PROFESSIONAL ENGINEER

David Cicia
2019.11.22
08:56:35-05'00'

NVCOG

Prepared for:
Naugatuck Valley Council of Governments

SCOUR ANALYSIS REPORT
Pedestrian Footbridge over Branch Brook

BL Project No. 1800579

Naugatuck River Greenway Multi-Use Trail
Towns of Watertown and Thomaston, CT

Prepared By:__________________ Date: 11/21/2019
Brandon Rojas

Checked By:__________________ Date: 11/21/2019
David Cicia

PREPARED BY:
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10th Floor
Hartford, CT 06103

BL Companies

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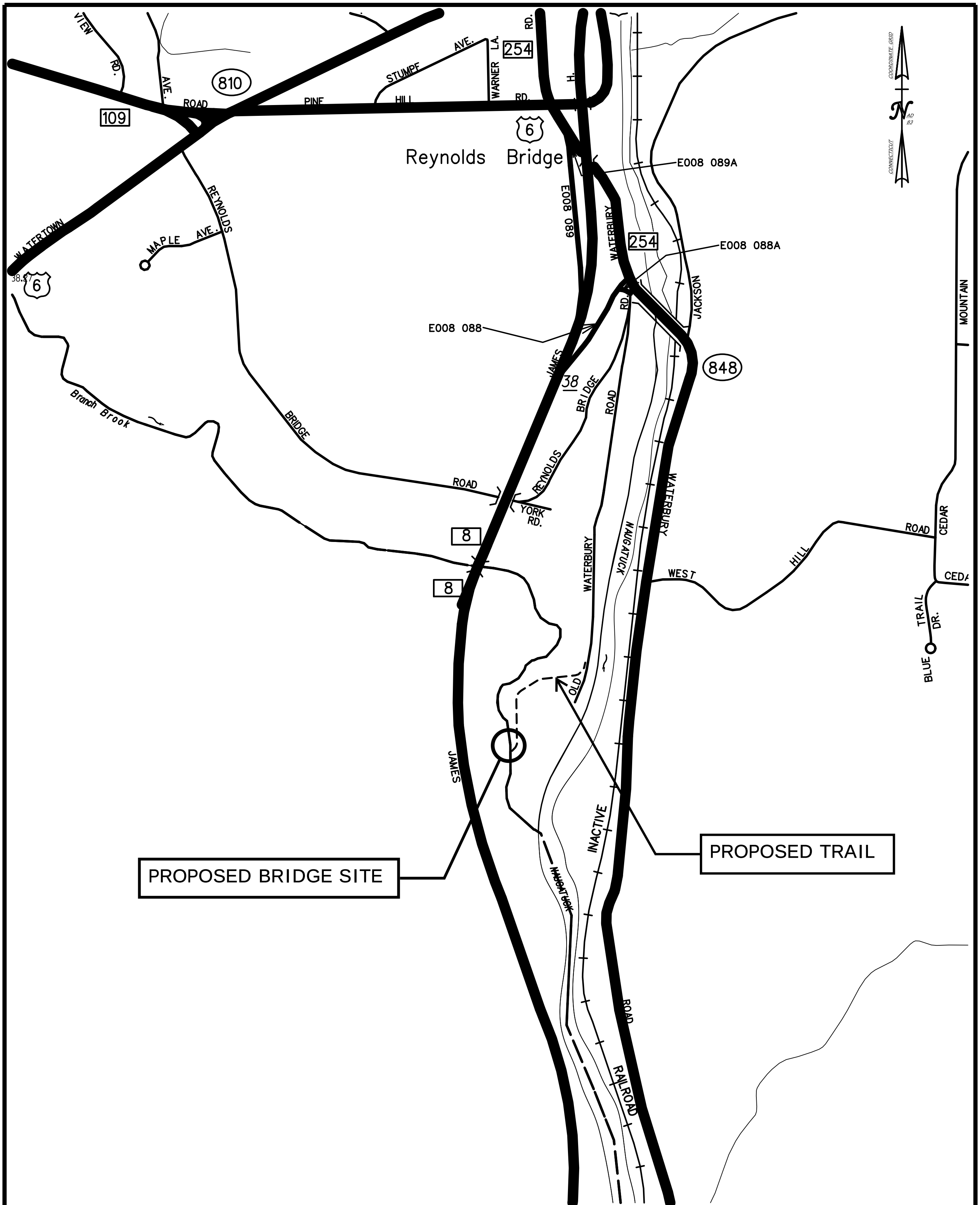


BL Companies	NAUGATUCK RIVER GREENWAY OVER BRANCH BROOK TOWNS OF WATERTOWN & THOMASTON, CONNECTICUT	LOCATION MAP	PROJ. NO.: 1800579 SCALE: 1" = 1,000'

II. EXECUTIVE SUMMARY

This project involves the construction of the Naugatuck River Greenway, a multi-use trail which includes a crossing over Branch Brook, a watercourse that forms the boundary between the towns of Watertown and Thomaston. The proposed trail is located east of Route 8 and west of the Naugatuck River. The trail crosses Branch Brook approximately 1,000 ft upstream of the brook's confluence with the Naugatuck River. Once the path crosses Branch Brook, it moves northeast just outside the ridgelines of the properties between the two watercourses (see Location Map), where it eventually connects to Old Waterbury Road.

There is currently no existing bridge at the site. As such, no field investigations performed by BL Companies have been taken beyond field survey observations and site data acquisition. There is little evidence of erosion, drift, or degradation in the studied reach. The existing channel contains all the studied storm events including the design and check storm events, while the structures outside the project area are hydraulically adequate during storm events.

For the 100-year design storm event, large structures are required to provide 1 ft of freeboard to the low point of the roadway edge and 2 ft of underclearance below the low chord of the bridge. Preliminary analysis indicates the proposed bridge is hydraulically adequate for all studied events.

BL Companies completed a Level II scour analysis conforming to Section 9.5 of the 2002 ConnDOT Drainage Manual and in accordance with FHWA HEC-18, "Evaluating Scour at Bridges", as amended by the 2002 ConnDOT Drainage Manual. Scour depths were computed for the 200 and 500-year storm events. The 500-year storm event has the highest computed scour depth.

A maximum total scour of 2.9 ft was calculated to occur during the 500-year storm event. The proposed abutments will be founded on spread footings. The footings will be placed approximately 4 ft below the grade along the abutments. Therefore, scour protection (rip rap) is not necessary.

BL Companies recommended NBIS 113 rating for the proposed bridge is 8. An Item 113 rating of 8 indicates the bridge foundations are determined to be stable for calculated scour conditions. The calculated scour is above the top of the abutment footings. BL Companies recommended NBIS 71 rating of 9 for the proposed bridge due to the remote chance of overtopping indicated in the preliminary hydraulic analysis. BL Companies recommended a NBIS 61 rating of 8 for the proposed bridge. The existing banks are well vegetated and embankment protection is not required.

EXECUTIVE SUMMARY TABLE PEDESTRIAN BRIDGE OVER BRANCH BROOK	
Recommended NBIS Rating Item 113	8 (Proposed Bridge)
Recommended NBIS Rating Item 71	9 (Proposed Bridge)
Recommended NBIS Rating Item 61	8 (Proposed Bridge)
Scour Risk Designation	Low Risk
Depth of Potential Scour	2.0 ft for a 200-Year Event
	2.9 ft for a 500-Year Event
Foundation Type	Reinforced Concrete Spread Footings
Analyzed/Assessed	Analyzed for Proposed Scour
Recommendation	Set Footings Below Calculated Scour
Future Action	N/A

III. PROPOSED CONDITIONS

Alternative 1 proposes building a prefabricated steel truss supported with reinforced concrete abutments and wingwalls. The new bridge will have a clear span of 60 ft and a low chord elevation of 331.25 ft. The bridge will have an approximate hydraulic opening area of 4,040 sq. ft.

There is little change to the computed 100-year water surface elevations for the existing condition without the bridge. The proposed bridge meets the “ConnDOT Drainage Manual” criteria for minimum freeboard of 1 ft or underclearance of 2 ft for large bridges.

The bridge will be used as a pedestrian footbridge. Due to the property impacts, constructability and proposed crossing use, the proposed structure was felt to be the best alternative.

IV. HYDROLOGY AND HYDRAULICS

At the proposed bridge site, Branch Brook has a drainage area of approximately 22.6 square miles. As published in the ConnDOT Drainage Manual, the bridge is classified as a large structure. Large structures provide waterway for drainage areas between 10 mi^2 and 1,000 mi^2. Table 1 below summarizes the approved peak flow discharges at the existing bridge location.

The flows were developed within the Flood Insurance Study for the Towns of Watertown and Thomaston were used for this analysis. For further information regarding the watershed characteristics and how the design flow was selected, please see Appendix A.

TABLE 1: SUMMARY OF FLOWS (C.F.S.)

Pedestrian Bridge over Branch Brook	
Year	**Project Flows**
2	450
10	800
50	800
100	900
200	1,500
500	2,300

Branch Brook is a relatively sinuous, channelized watercourse, flowing from northwest to southeast through the project site. The normal stream channel is between approximately 35 to 40-ft wide through this section. Both banks are heavily vegetated with trees and light groundcover.

For information on the hydraulics of the existing and proposed structure, please refer to the Preliminary Hydraulic Analysis Report, submitted under a separate cover.

V. SCOUR ANALYSIS RESULTS

BL Companies completed a Level II scour analysis conforming to Section 9.5 of the 2002 ConnDOT Drainage Manual and in accordance with FHWA HEC-18, "Evaluating Scour at Bridges", as amended by the 2002 ConnDOT Drainage Manual. Scour depths were computed for the 200-year and 500-year storm events.

During each studied storm event, the bridge experiences abutment scour. For the Naugatuck River Greenway crossing, the highest scour computed occurred during the 500-year storm event.

Contraction scour occurs when the flow area of a stream at flood stage is reduced, either by a natural condition or by a bridge. A decrease in flow area results in an increase in average velocity and bed shear stress through the contracted section. Although the river's flow is constricted at the bridge, there is no computed contraction scour. The clear-water contraction scour calculations control and these calculations show no expected contraction scour. The contraction scour computations are included in Appendix D.

The contraction scour calculations are based on an assumed D_{50} size. The D_{50} size (0.125 ft) was selected after a field visit. The channel bottom is lined naturally with gravelly sand over small cobbles and boulders.

Local scour occurs around abutments and is caused by the acceleration of the flow and the development of vortex systems inducted by obstructions to flow. The magnitude of local scour at an abutment is a function of the alignment of the abutment, the streambed material, and the amount of overbank flow that returns to the main channel at the bridge section. The local scour depths computed at each abutment are included in Table 2 and the detailed computations are included in Appendix D.

Pressure flow scour occurs when the upstream water surface rises above the low chord of the bridge. This forces water to plunge downward as it is forced through the bridge opening. The pressure flow scour depths were computed for all storm events. Each storm event computed a negative amount of pressure flow scour

Scour calculations were also completed utilizing the National Cooperative Highway Research Program (NCHRP) equations. The NCHRP equations compute total scour at the bridge (abutment scour plus contraction scour). The NCHRP scour depths computed are included in Table 2 and the detailed computations are included in Appendix D. The NCHRP calculations were not used as the basis for design.

TABLE 2: SCOUR ANALYSIS RESULTS

Frequency Event (Years)	Contraction Scour (ft)	Left (West) Abutment Scour (ft)	Right (East) Abutment Scour (ft)	NCHRP Scour (ft)	Pressure Flow Scour (ft)	Total Scour (ft)
200	0.0	0.5	2.0	2.1	-	2.0
500	0.0	0.4	2.9	3.8	-	2.9

The scour analysis indicates that a maximum total scour of 2.9 ft could occur during a 500-year storm event. During this event, the local abutment scour analysis indicates a potential scour depth of 0.4 ft at the left abutment and 2.9 ft at the right abutment. The total scour depth 2.0 ft for the 200-year storm event.

During all studied storm events (including the condition just prior to roadway overtopping, the bridge remains hydraulically adequate.

The top of the proposed footings is located at a depth of approximately 4 ft below the ground elevation at the abutments. The footings are a 24” thickness.

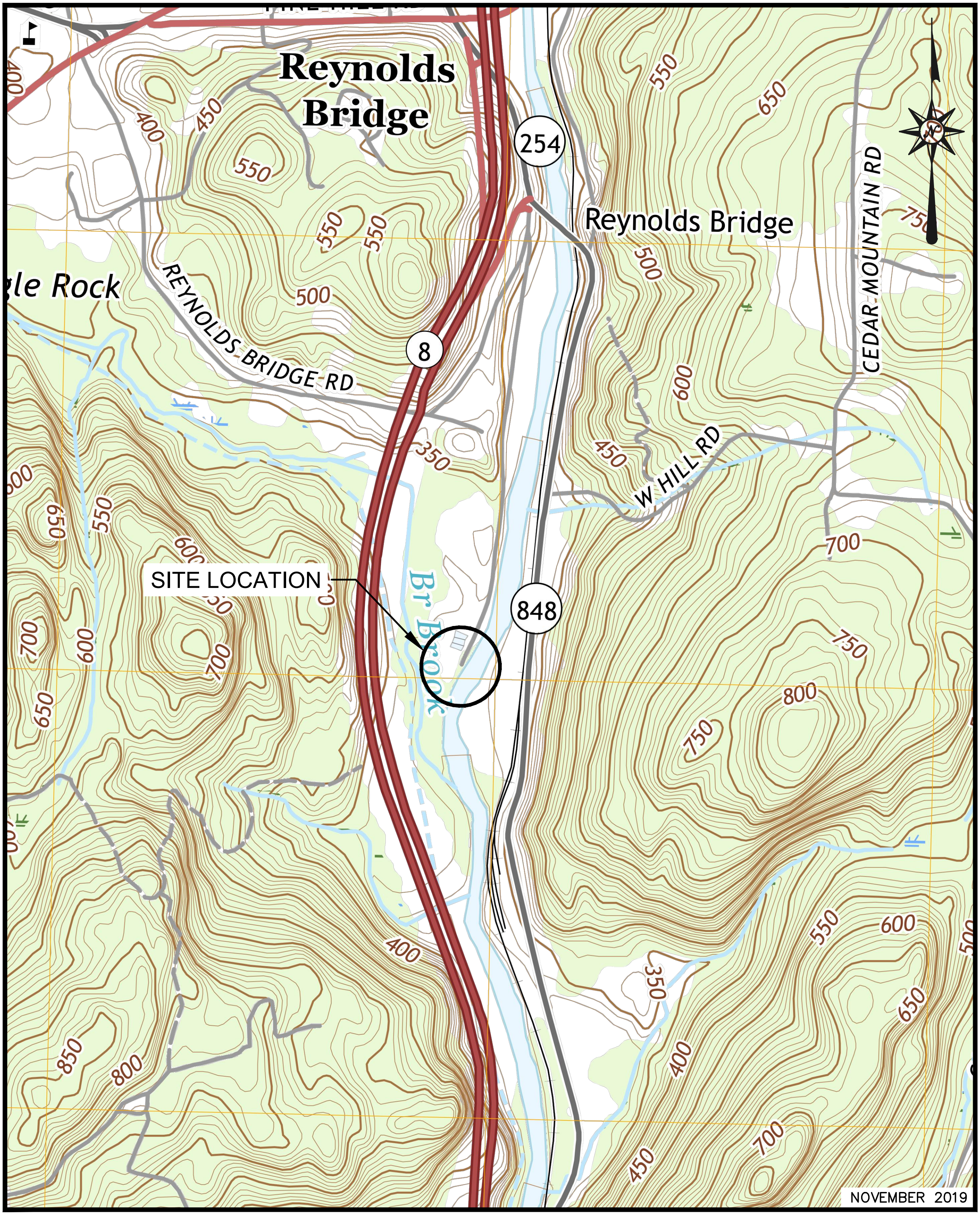
The proposed bridge will be designed to withstand the predicted scour, including construction of foundations to sufficient depth. Inspection of the abutments after significant storm events is recommended to ensure that the installed riprap countermeasure remains in place and continues to protect the bridge. Based on the predicted scour calculations, a significant storm event should include 200-year storm events and above.

The BL Companies recommended NBIS 71 rating for the proposed bridge is 9, due to the hydraulic adequacy and proposed use. The BL Companies recommended NBIS 61 rating for the proposed bridge is 8. The existing banks are well vegetated and embankment protection is not required in most areas.

VI. STREAM STABILITY

The stability of Branch Brook in the vicinity of the proposed bridge was assessed according to the guidelines established in FHWA's "Stream Stability at Highway Structures" (HEC-20). Factors that affect stream stability, and potentially bridge stability at highway stream crossings, can be classified as geomorphic factors and hydraulic factors.

The stream stability and the rate of change in a stream are dependent on the material in the bed and banks. The publication was used as a guide for this analysis. The geomorphic factors observed during site investigations are summarized in Appendix C. The banks both upstream and downstream are heavily covered with low-lying vegetation. Upon field investigations, the channel banks upstream and downstream were observed to be stable.



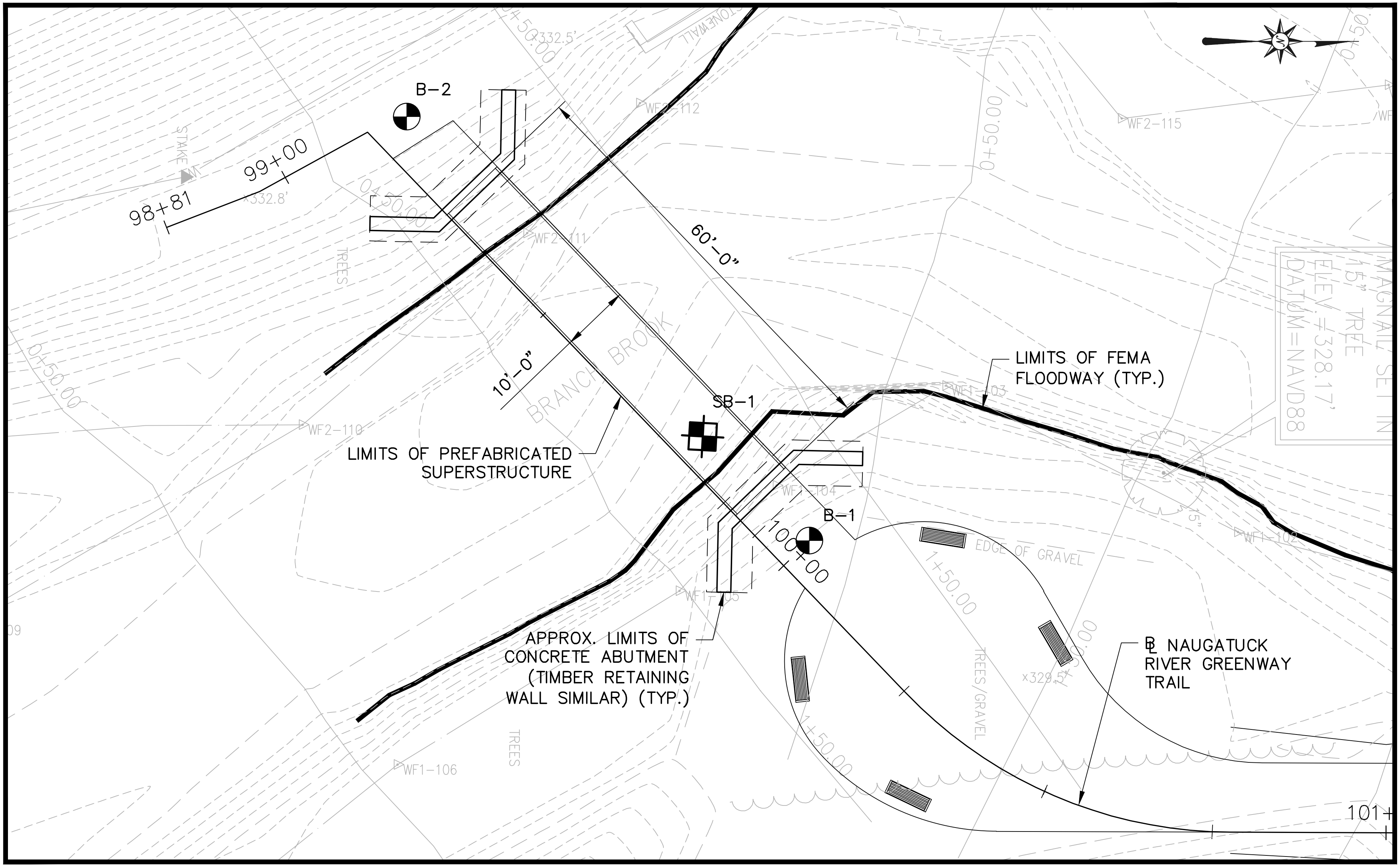
USGS LOCATION MAP
NAUGATUCK RIVER GREENWAY PEDESTRIAN
BRIDGE OVER BRANCH BROOK
THOMASTON, CT

SCALE: 1" = 1000'

BL Companies

FIGURE 1

CAD File: TLOC180057901.dwg



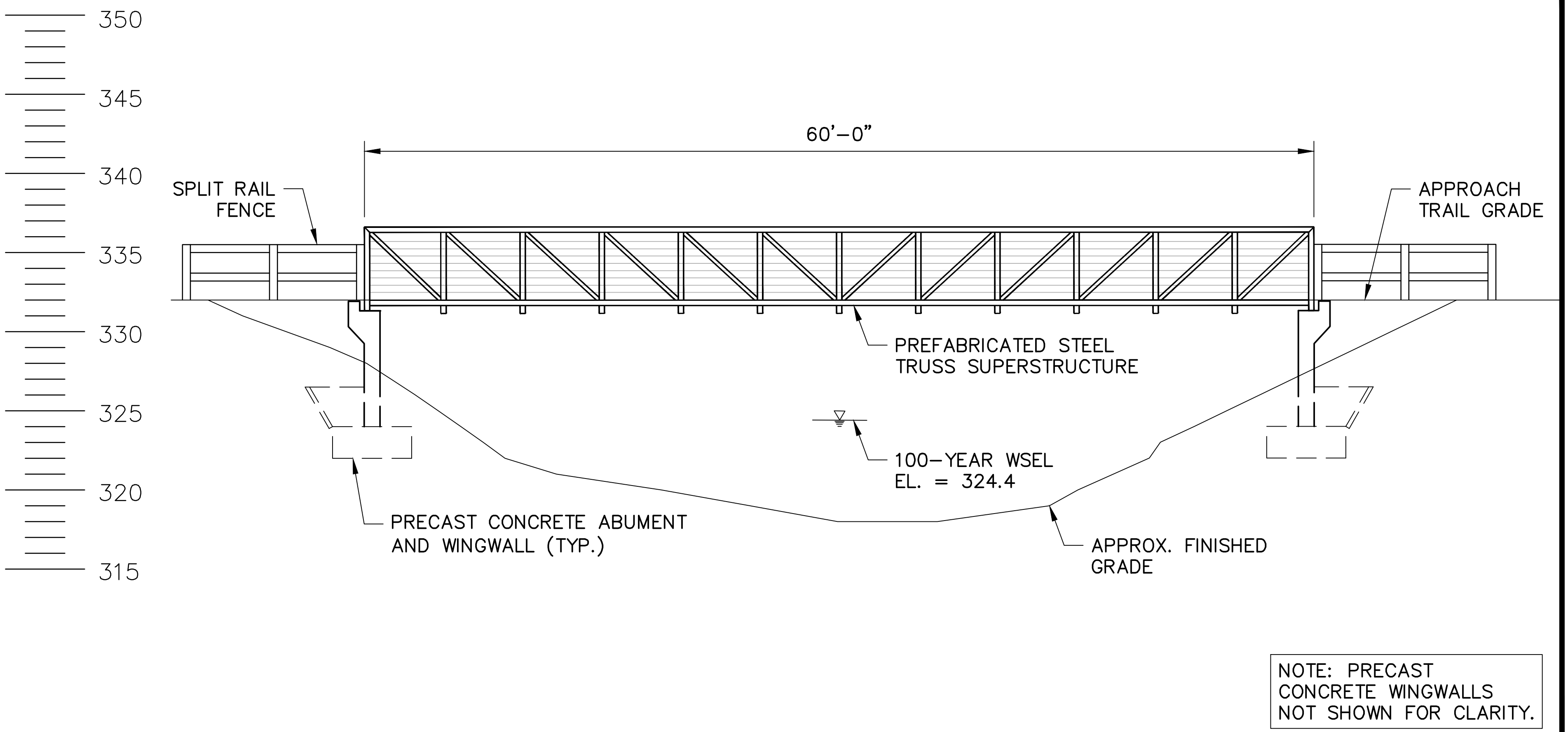
BL Companies

PROPOSED BRIDGE LOCATION

NAUGATUCK RIVER GREENWAY PEDESTRIAN BRIDGE OVER BRANCH BROOK
THOMASTON, CONNECTICUT

Designed	M.W.
Drawn	T.B.
Checked	M.W.
Approved	C.P.
Scale	1" = 20'-0"
Project No.	1800579
Date	11/2019
CAD File	Structure Type Study Figures

FIG. 2



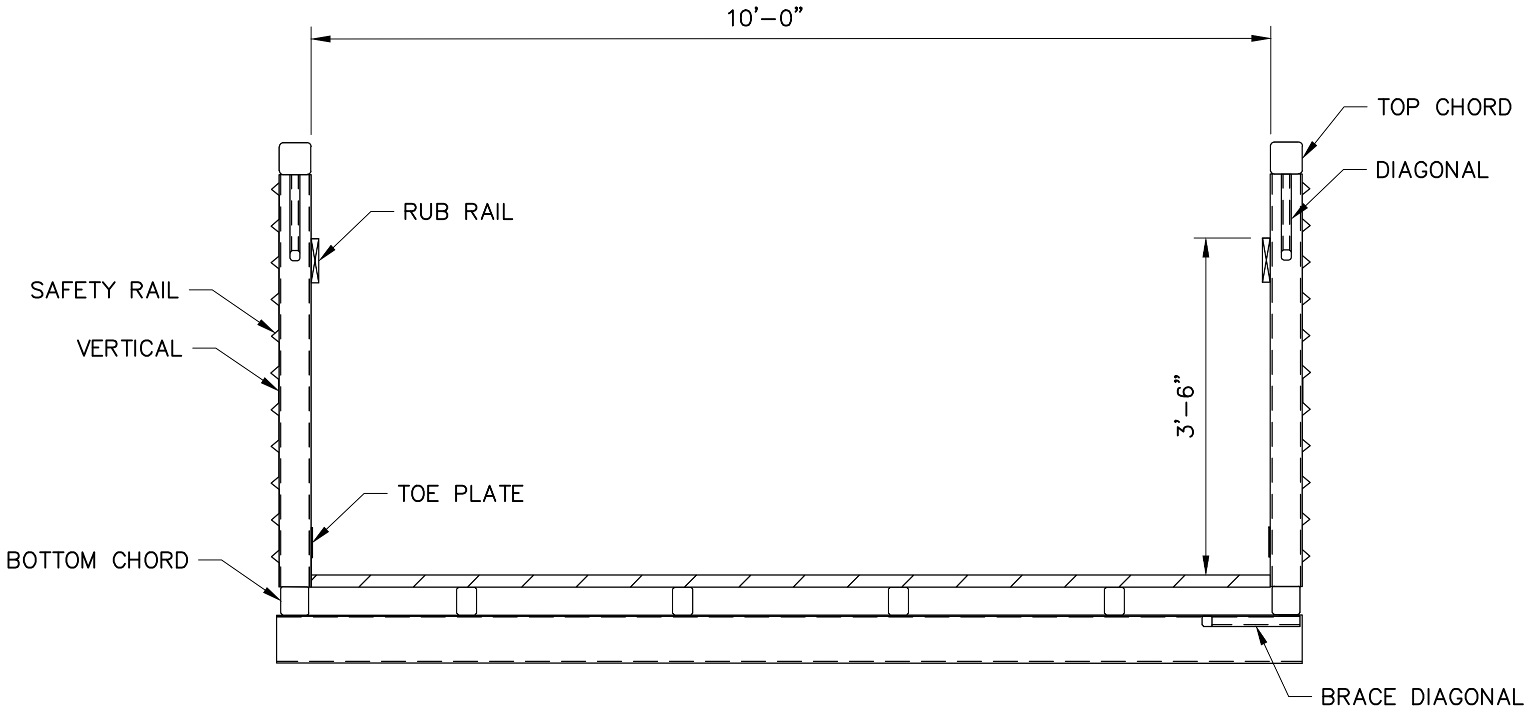
BL Companies

ALTERNATIVE 1 - DOWNSTREAM ELEVATION

NAUGATUCK RIVER GREENWAY PEDESTRIAN
BRIDGE OVER BRANCH BROOK
THOMASTON, CONNECTICUT

Designed	M.W.
Drawn	T.B.
Checked	M.W.
Approved	C.P.
Scale	1" = 10'-0"
Project No.	1800579
Date	11/2019
CAD File	Structure Type Study Figures

FIG. 3



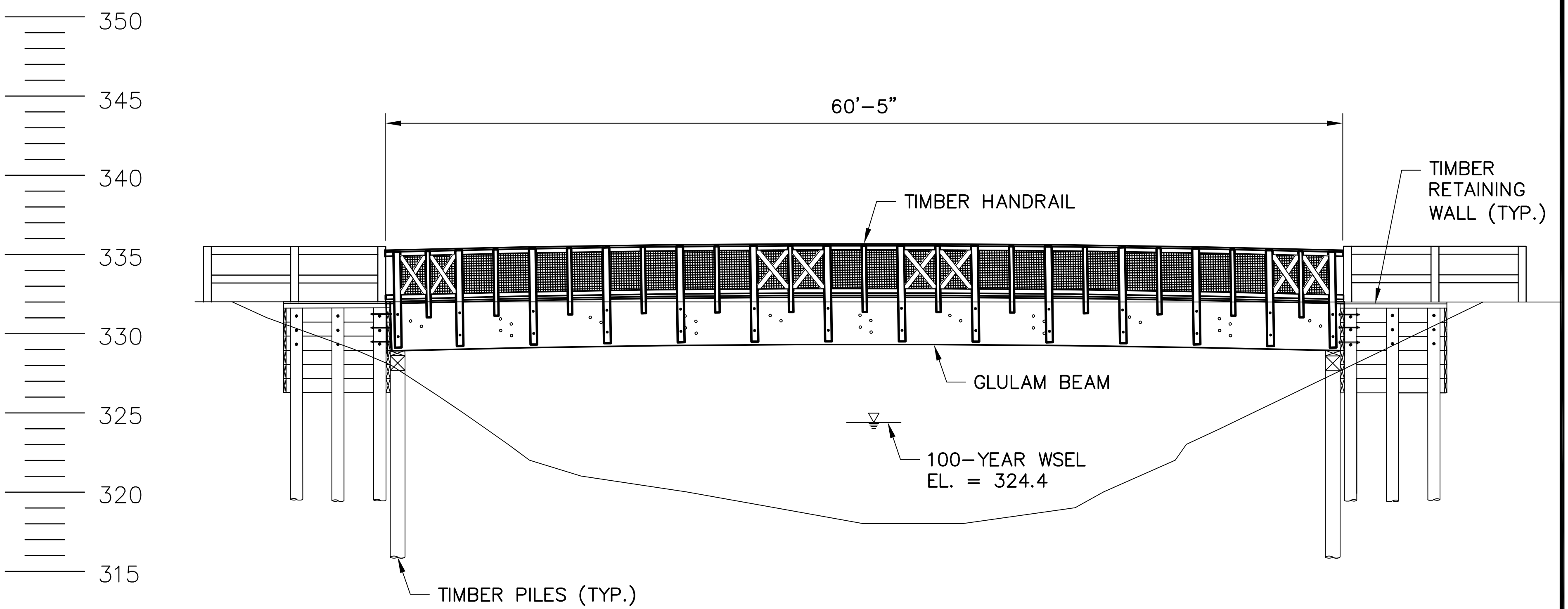
BL Companies

ALTERNATIVE 1 - TYPICAL SECTION

NAUGATUCK RIVER GREENWAY PEDESTRIAN
BRIDGE OVER BRANCH BROOK
THOMASTON, CONNECTICUT

Designed	M.W.
Drawn	T.B.
Checked	M.W.
Approved	C.P.
Scale	1/2" = 1'–0"
Project No.	1800579
Date	11/2019
CAD File	Structure Type Study Figures

FIG. 4



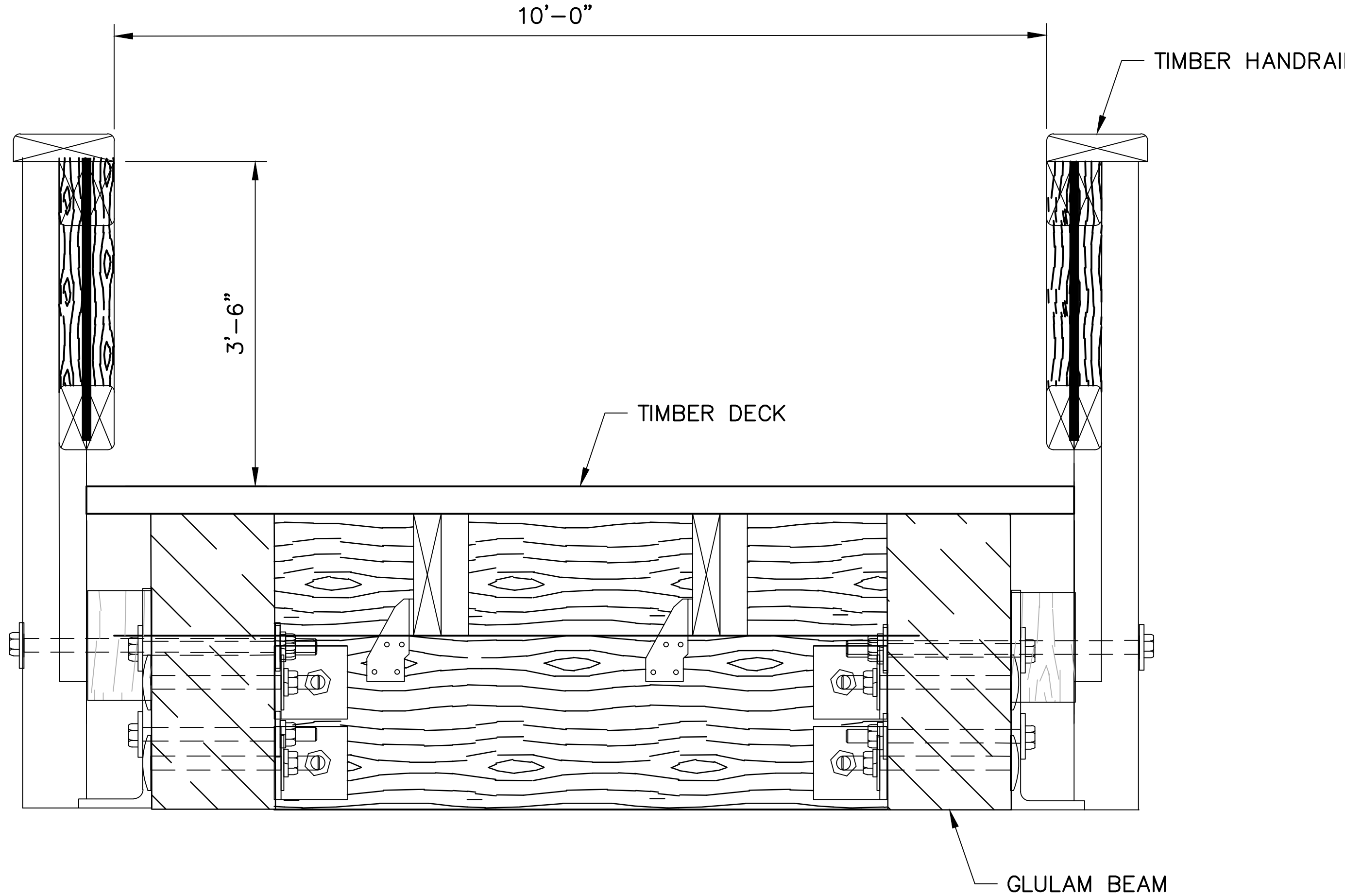
BL Companies

ALTERNATIVE 2 - DOWNSTREAM ELEVATION

NAUGATUCK RIVER GREENWAY PEDESTRIAN
BRIDGE OVER BRANCH BROOK
THOMASTON, CONNECTICUT

Designed	M.W.
Drawn	T.B.
Checked	M.W.
Approved	C.P.
Scale	1" = 10'-0"
Project No.	1800579
Date	11/2019
CAD File	XBRG1800579_101

FIG. 5



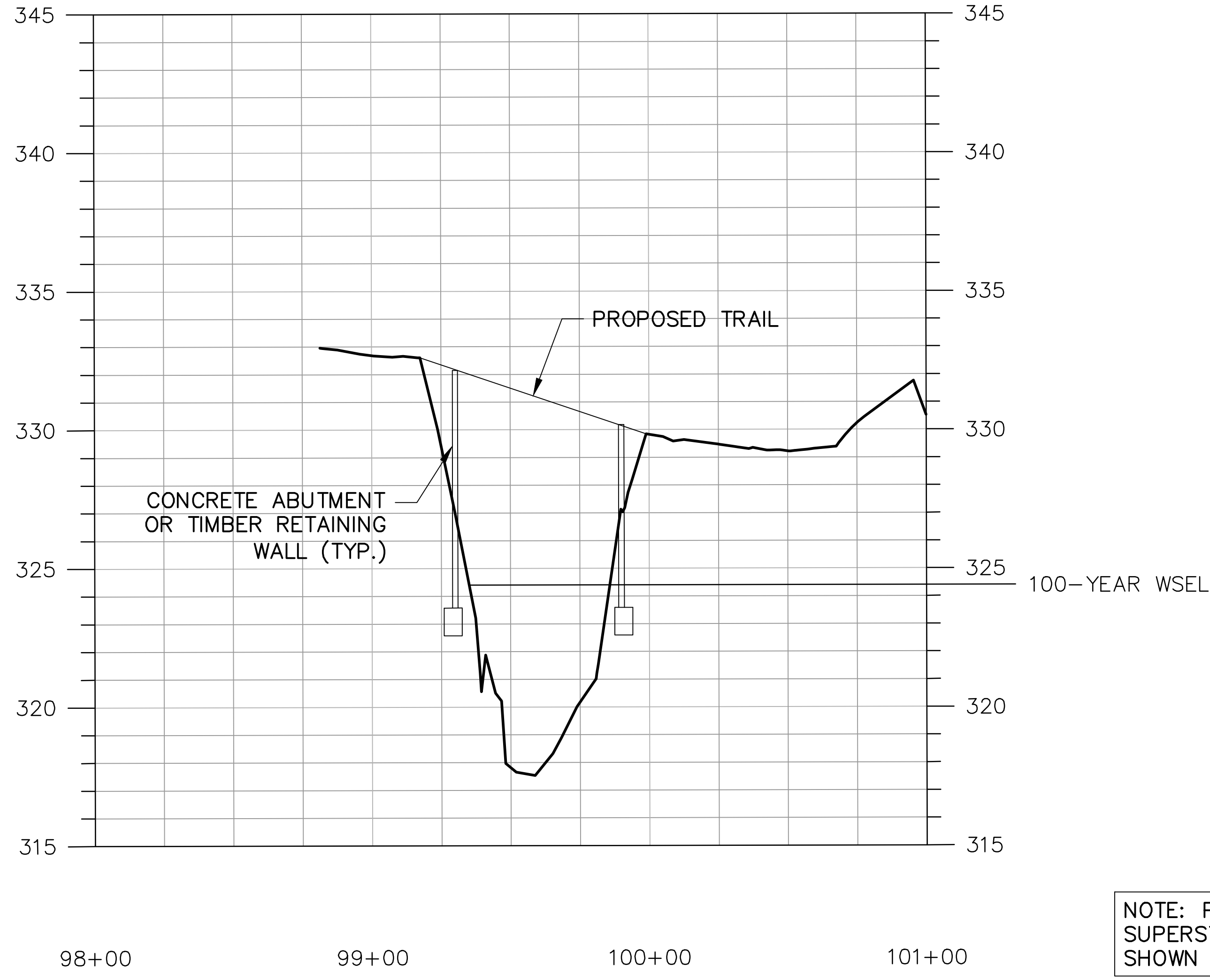
BL Companies

ALTERNATIVE 2 - TYPICAL SECTION

NAUGATUCK RIVER GREENWAY PEDESTRIAN
BRIDGE OVER BRANCH BROOK
THOMASTON, CONNECTICUT

Designed	M.W.
Drawn	T.B.
Checked	M.W.
Approved	C.P.
Scale	1/2" = 1'–0"
Project No.	1800579
Date	11/2019
CAD File	Structure Type Study Figures

FIG. 6



NOTE: PREFABRICATED SUPERSTRUCTURE NOT SHOWN FOR CLARITY.

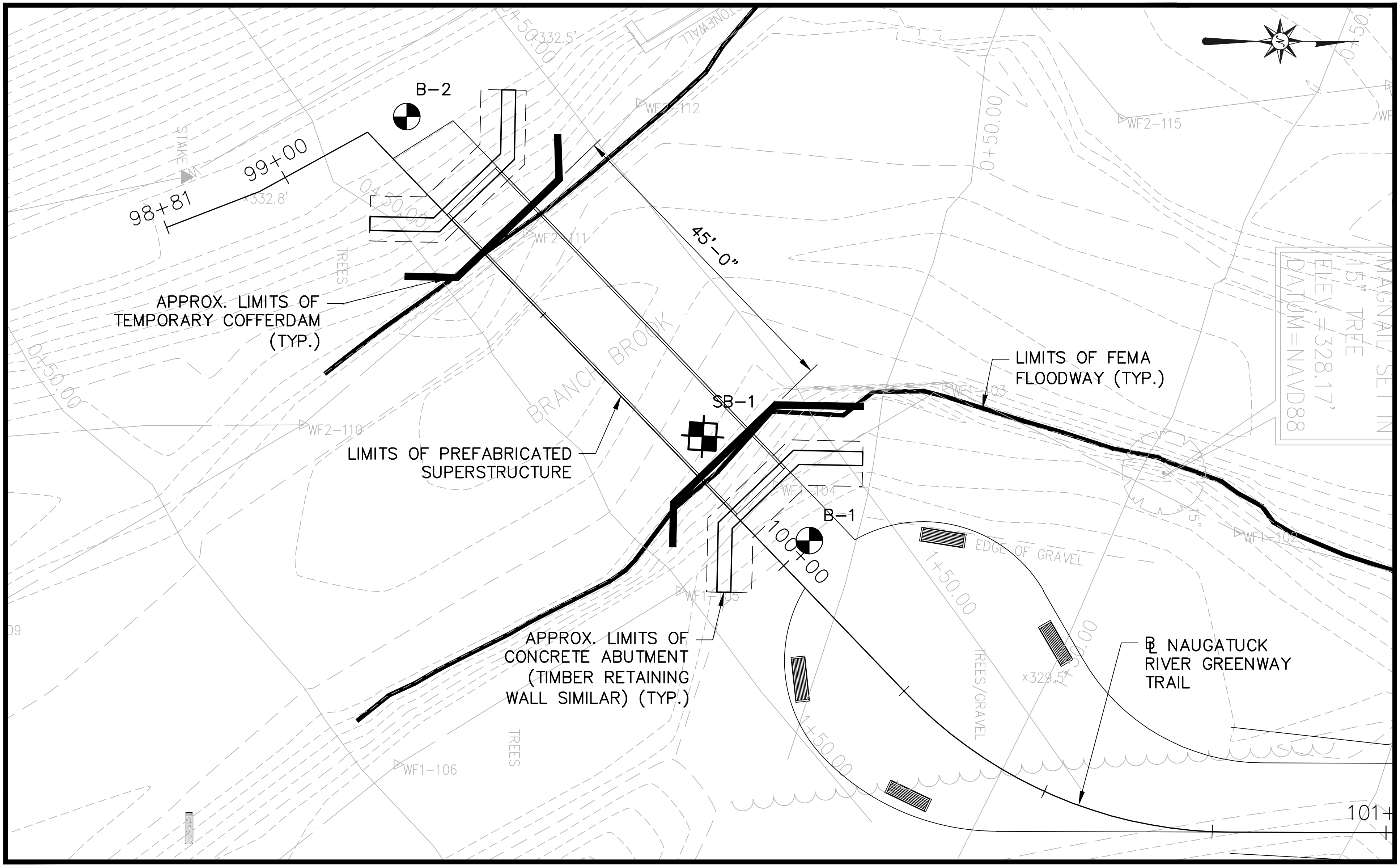
BL Companies

PROFILE

NAUGATUCK RIVER GREENWAY PEDESTRIAN
BRIDGE OVER BRANCH BROOK
THOMASTON, CONNECTICUT

Designed	M.W.
Drawn	T.B.
Checked	M.W.
Approved	C.P.
Scale	N.T.S.
Project No.	1800579
Date	10/2019
CAD File	Structure Type Study Figures

FIG. 7



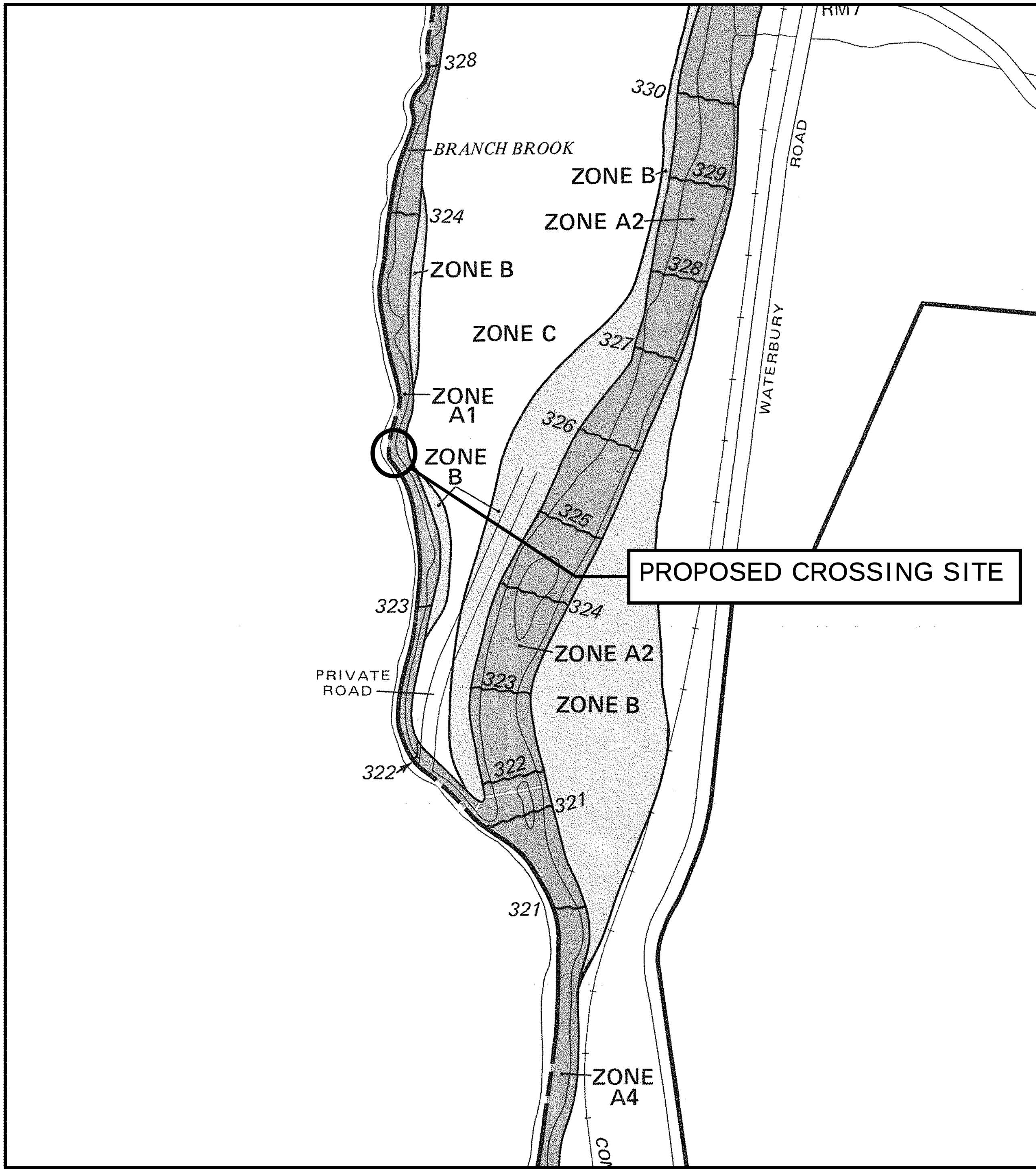
BL Companies

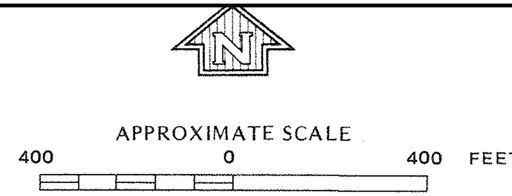
PROPOSE BRIDGE LOCATION WITH TEMPORARY CONDITIONS

NAUGATUCK RIVER GREENWAY PEDESTRIAN
BRIDGE OVER BRANCH BROOK
THOMASTON, CONNECTICUT

Designed	M.W.
Drawn	T.B.
Checked	M.W.
Approved	C.P.
Scale	1" = 20'-0"
Project No.	1800579
Date	11/2019
CAD File	Structure Type Study Figures

FIG. 8





NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

TOWN OF
THOMASTON,
CONNECTICUT
LITCHFIELD COUNTY

PANEL 5 OF 6
(SEE MAP INDEX FOR PANELS NOT PRINTED)

COMMUNITY-PANEL NUMBER
090055 0005 B

EFFECTIVE DATE:
JULY 5, 1982

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

APPENDIX A – HYDROLOGY

October 2019

ConnDOT Approved Hydraulic Engineer:

NVCOG

Prepared for:
Naugatuck Valley Council of Governments

HYDROLOGIC ANALYSIS REPORT
Pedestrian Footbridge over Branch Brook

BL Project No. 1800579

Naugatuck River Greenway Multi-Use Trail
Towns of Watertown and Thomaston, CT

Prepared By:__________ Date: 10/14/2019
Brandon Rojas

Checked By:__________ Date: 10/15/2019
David Cicia

PREPARED BY:
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Hartford, CT 06103

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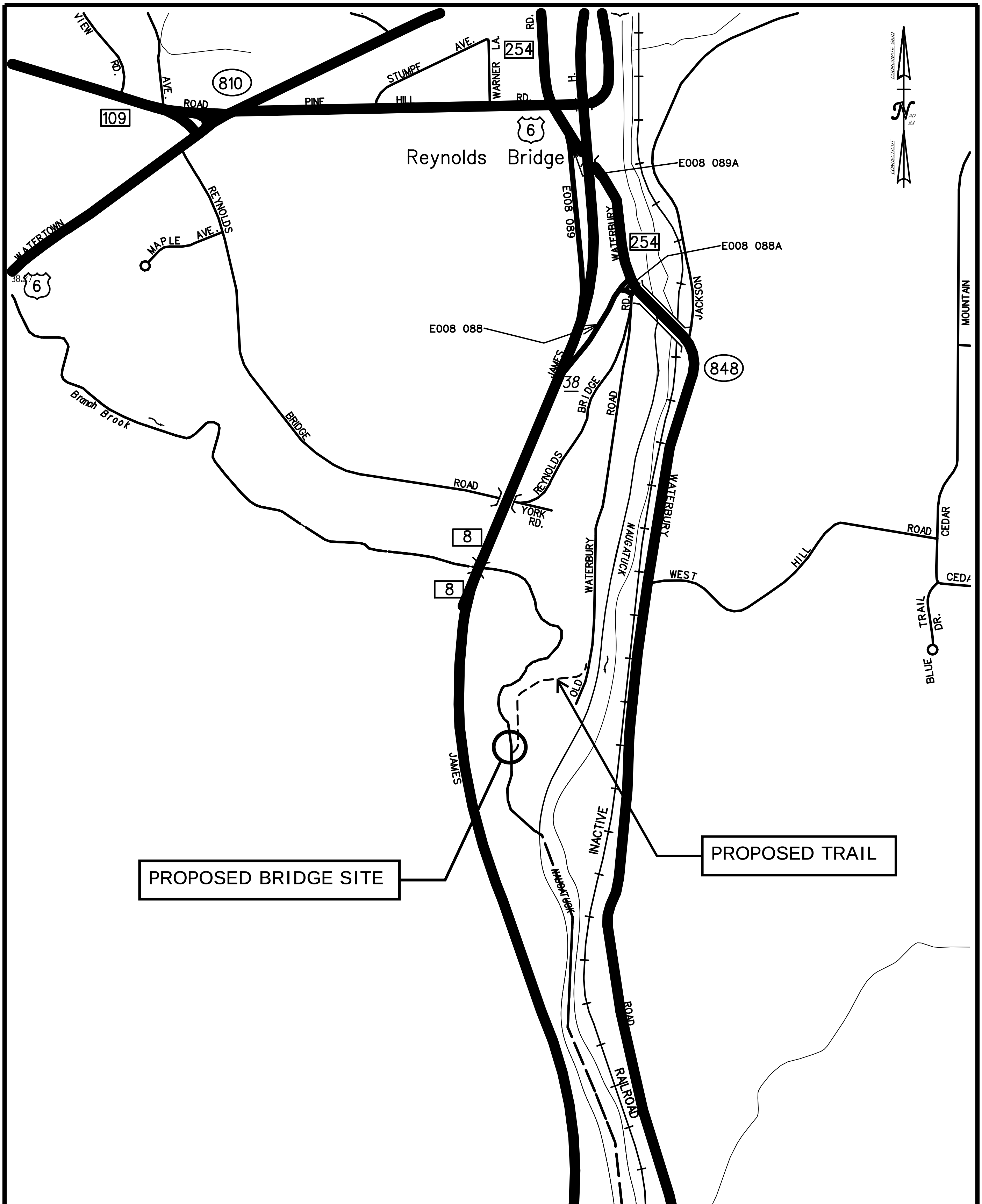


Companies

NAUGATUCK RIVER GREENWAY
OVER BRANCH BROOK
TOWNS OF WATERTOWN &
THOMASTON, CONNECTICUT

LOCATION MAP

PROJ. NO.: 1800579

SCALE: 1" = 1,000'

II. WATERSHED CHARACTERISTICS

This project involves the construction of the Naugatuck River Greenway, a multi-use trail which includes a crossing over Branch Brook, which forms the boundary between the towns of Watertown and Thomaston. The proposed trail is located east of Route 8 and west of the Naugatuck River. The trail crosses Branch Brook approximately 1,000 ft upstream of the brook's confluence with the Naugatuck River. Once the path crosses Branch Brook, it moves northeast just outside the ridgelines of the properties between the two watercourses (see Location Map), where it eventually connects to Old Waterbury Road.

Branch Brook flows primarily southeast, beginning just downstream of the Wigwam Reservoir Dam, located approximately 3.0 miles upstream from the confluence of Branch Brook and Naugatuck River. Beyond this point (upstream direction), the main watercourse is segmented into a series of reservoirs and several dams, each with branching tributaries contributing to the watershed. As a result of the large water storage area, typical flow estimation methods involving StreamStats are not feasible and will not be used in this analysis. The largest watercourses within this area by extension (not including Branch Brook) are: Wigwam River, Moosehorn Brook, Slab Meadow Brook, East Morris Brook and Fenn Brook.

The river upstream of the bridge has an average streambed slope of 29.3 ft/mi. At the site of the proposed bridge, the brook has a drainage area of approximately 22.6 square miles. The watershed was generated by the USGS StreamStats 4.2 online application and revised for accuracy using USGS Quadrangle Maps from the National Map online viewer (see Figure 2). Utilizing the USGS StreamStats online utility, the watershed area exhibits that 9.69% of the land use is developed, 1.07% is wetlands and the remainder is forested or other pervious area. Delineation of surficial materials indicates that approximately 2.21% of the watershed area consists of coarse-grained stratified drift (see Figure 3) and the remainder is composed of various postglacial deposits and till.

The watershed extends northwest to a local high point located approximately 1.1 miles east of the intersection of Route 118 and Route 202. The eastern side of the watershed follows a ridgeline south, bordering the western limits of the larger Naugatuck River watershed. These extents of the watershed continue along a series of high points within the Towns of Litchfield, Thomaston and Watertown until it meets the location of the proposed pedestrian footbridge. The western extents of the watershed move from the northern portion of the watershed south along a series of high points until the southernmost limits, following the limits of the various watersheds surrounding the subject area. The southern extents of the watershed move along ridgelines until connecting with the eastern watershed limits at the bridge.

The upper third of the watershed is characterized by large amounts of rural pasture area unlike the other two thirds of the watershed which are mostly wooded and remote. The middle third consists of rural residential area as well as some open pasture. This area also includes large undeveloped wooded and water storage areas, including multiple large reservoirs such as Morris Reservoir and Pitch Reservoir. The lower third is similar in composition to the middle third of the watershed, characterized by large areas of water storage and forested area, although with substantially less open pasture-like area. This portion of the watershed contains the Branch

Brook watercourse, Black Rock Reservoir and the bridge itself. The ConnDOT Drainage Manual classifies the proposed bridge as a large structure (providing waterway for drainage areas of more than 10 square miles and less than 1,000 square miles) with a 100-year design storm event and a 500-year check storm event. The bridge is within Zone A1 on the FEMA Flood Insurance Rate Map (see Figure 4).

The FEMA Flood Insurance Study (*FIS*) denotes an area of 20.8 square miles, approximately 1.75 miles upstream of the bridge site at Black Rock Dam (effectively the beginning of the Branch Brook watercourse). The brook is listed in the Gazetteer of Drainage Areas of Connecticut. At the brook's mouth above Naugatuck River, the gazetteer lists Branch Brook with a drainage area of 22.646 sq. mi. The mouth is located approximately 1,100 feet downstream (south) of the subject bridge. There is also a USGS stream gage approximately 1.25 miles upstream from the proposed bridge.

III. HYDROLOGIC METHODOLOGY

The flows in this hydrologic study were prepared utilizing the methods described below:

1. **Method 1 – FEMA Flood Insurance Study (*FIS*):** This data was obtained from the *Flood Insurance Study (FIS), Prepared for the Town of Watertown, Connecticut, revised May 1980 by the Federal Emergency Management Agency* (FEMA). The *FIS* contains published flows along Branch Brook at three locations along the watercourse: at the mouth of the brook (the confluence with the Naugatuck River), at Black Rock Dam and at Wigwam Dam. At these locations, the drainage areas listed in the *FIS* are 22.8, 20.4, and 17.5 sq. miles, respectively. Black Rock Dam is the first structure upstream of the proposed bridge location. It is composed of a 933-ft long and 154-ft high earthen dam, a gated 4-ft by 5-ft concrete conduit in the right abutment of the dam, and a chute spillway with a 140-ft long crest adjacent to the right abutment. The structure has storage equivalent to 8 inches of runoff from the drainage area of 20.4 sq. miles. According to the *FIS,* the flows at Black Rock Dam are estimated based on hydrographs of major events routed through the reservoir. Refer to Appendix B of this report for additional *Flood Insurance Study* information. The *FIS* flows will be utilized for the hydraulic analysis.

2. **Method 2 – PeakFq Gage Analysis:** A gage analysis was performed on Gage No. 01208013 – Branch Brook near Thomaston, CT. The USGS program PeakFq, Version 7.2, computed estimates for the gages based on the Expected Moments Algorithm (EMA). Gage flow information was found in StreamStats, and is listed in the USGS publication, *Regression Equations for Estimating Flood Flows for the 2-, 10-, 25-, 50-, 100-, and 500-Year Recurrence Intervals in Connecticut, Report 2004-5126 (Ahearn, 2004)*. Refer to Appendix D for analysis of the stream gage in PeakFq. The flows computed by PeakFq and transferred to the site using the CTDOT Drainage Manual's flow transfer equation will not be utilized for the hydraulic analysis.

The flows calculated using the above methods are listed in "Table 1: Summary of Flows".

IV. HISTORICAL FLOODING

Numerous major floods have occurred within the Naugatuck River Basin, many of which caused severe damage to property and even loss of life. According to the FEMA *FIS*, the major floods of the century within the watershed occurred in August 1955 which saw the failure of multiple dams and bridges. This includes the downstream reaches of the Thomaston Dam where the Naugatuck River claimed an estimated 36 lives and caused damages estimated at $193,000,000. Stream flow records at the USGS gaging station along upstream of Black Rock Dam indicate that the August 1955 flood was greater than that of a 100-year event (*FIS*). Refer to Atlas 14 data (see Appendix E) to view relevant rainfall data.

V. STUDY RESULTS

The flows provided in the FEMA *Flood Insurance Study* at the mouth of Branch Brook will be utilized as the design flows for the hydraulic analysis. The FEMA and PeakFq rates are similar for all but the 500-year event. As noted in the *FIS*, the FEMA discharges for the 100-year and 500-year events "are estimated based on hydrographs of major events routed through the reservoir". The PeakFq flows are from a regression-based analysis and the 500-year flow appears too low for use. The flows within the *FIS* at the mouth of Branch Brook appear most accurate for the nature and use of the contributing watershed.

TABLE 1: SUMMARY OF FLOWS (C.F.S.)

Summary of Flows (cfs) vs. Design Frequency (years) Pedestrian Bridge over Branch Brook – Watertown/Thomaston, CT								
	Drainage Area (mi^2)	2-Year	10-Year	25-Year	50-Year	100-Year	200-Year	500-Year
FEMA at Branch Brook mouth	22.8	-	800	-	800	900	-	2,300
FEMA at Black Rock Dam	20.4	-	800	-	800	900	-	2,300
PeakFq at Gage - No. 01208013	22.6	560	770	870	940	1,010	1,080	1,180

As previously mentioned, the proposed bridge is classified as a large structure. Large structures have a 100-year design storm event and a 500-year check storm event. At the location of the proposed bridge, the selected method has a 100-year flow of 900 cfs and a 500-year flow of 2,300 cfs. See Table 2 for the design flows recommended for this project.

TABLE 2: DESIGN FLOWS (C.F.S.)

Design Flows (cfs) vs. Design Frequency (years) Aircraft Road Bridge over Quinnipiac River – Southington, CT	
Year	**Flow**
Average Daily Flow	40
Average Spring Flow	80
2	450*
5	560*
10	800
25	800*
50	800
100 (Design Storm Event)	900
200	1,500*
500 (Check Storm Event)	2,300

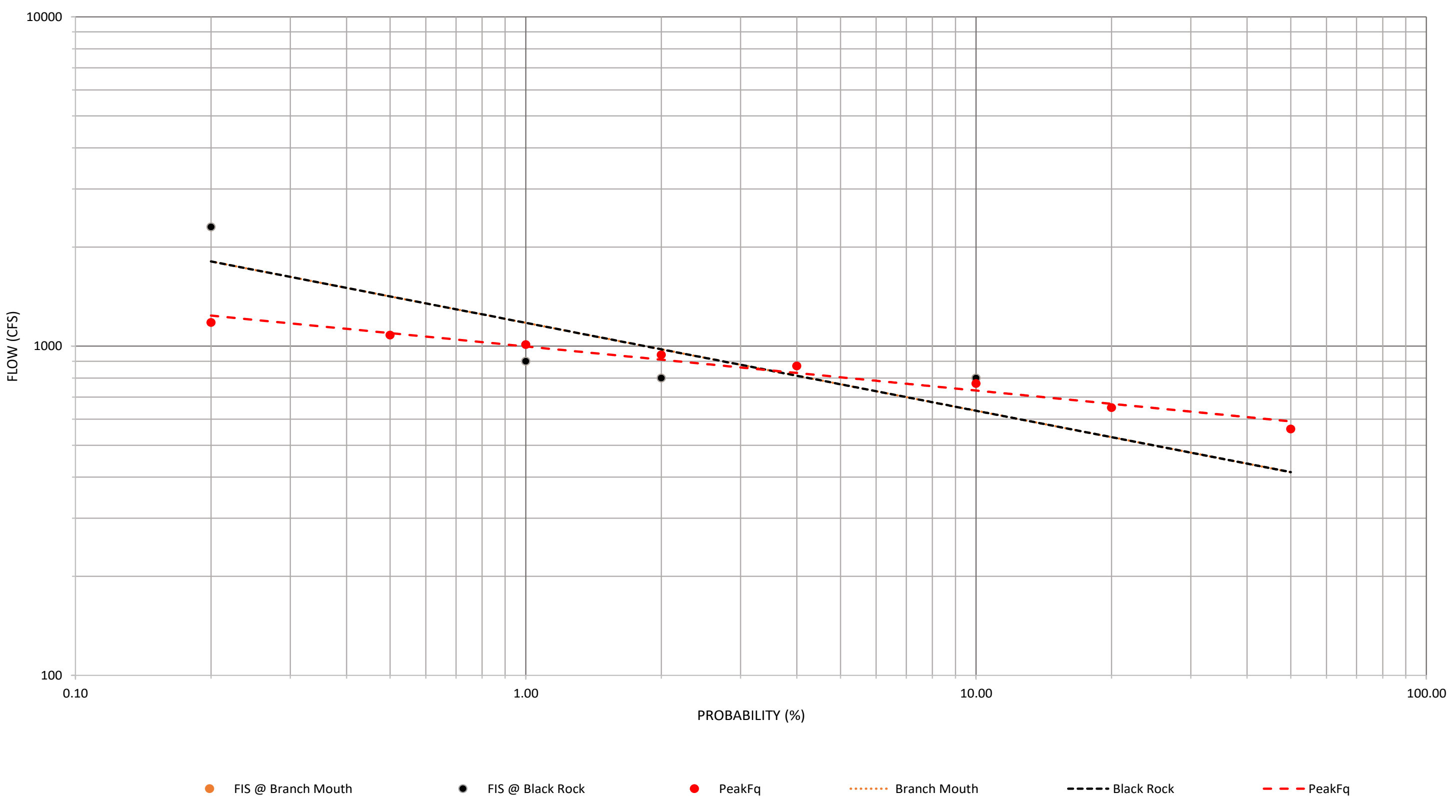
*These values were obtained based on a linear evaluation of the logarithmic chart.

To comply with the National Flood Insurance Program and the CT DEEP hydraulic guidelines for work within a regulated floodway, the FEMA FIS flows will also be used in the floodway analysis.

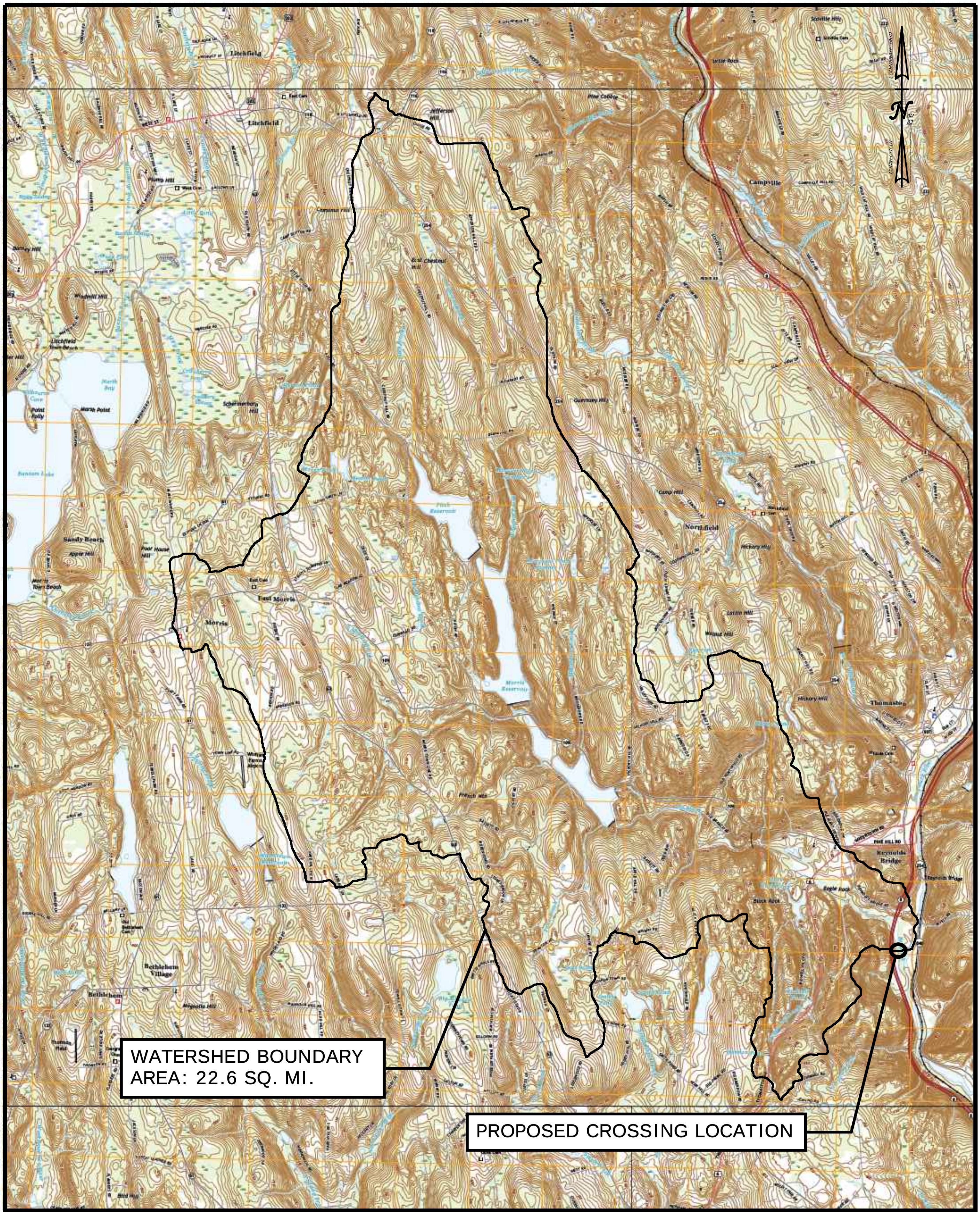
Companies
100 Constitution Plaza, 10th Floor
Hartford, Connecticut 06103

PROJECT: **Naugatuck River Greenway Multi-Use Trail**
Towns of Watertown & Thomaston, CT
PREPARED BY: Brandon Rojas
CHECKED BY: David Cicia

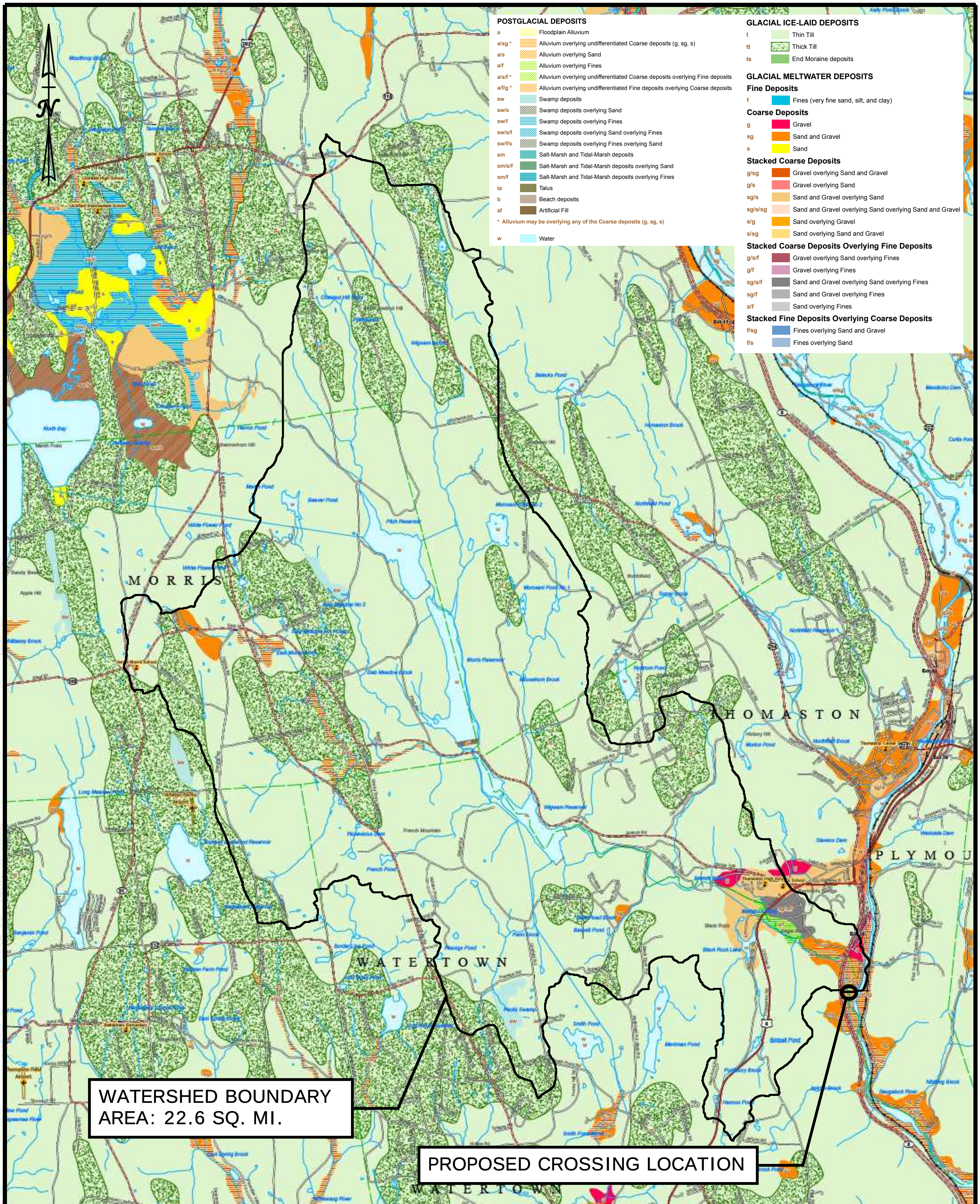
Year		PROBABILITY (%)	FEMA FIS at mouth of Branch Brook	FEMA FIS at Black Rock Dam	PeakFq at USGS Stream Gage No. 1208013
2	0.5	50			560
5	0.2	20			650
10	0.1	10	800	800	770
25	0.04	4			870
50	0.02	2	800	800	940
100	0.01	1	900	900	1,010
200	0.005	0.5			1,080
500	0.002	0.2	2,300	2,300	1,180



PROBABILITY CHART FOR ALL METHODS

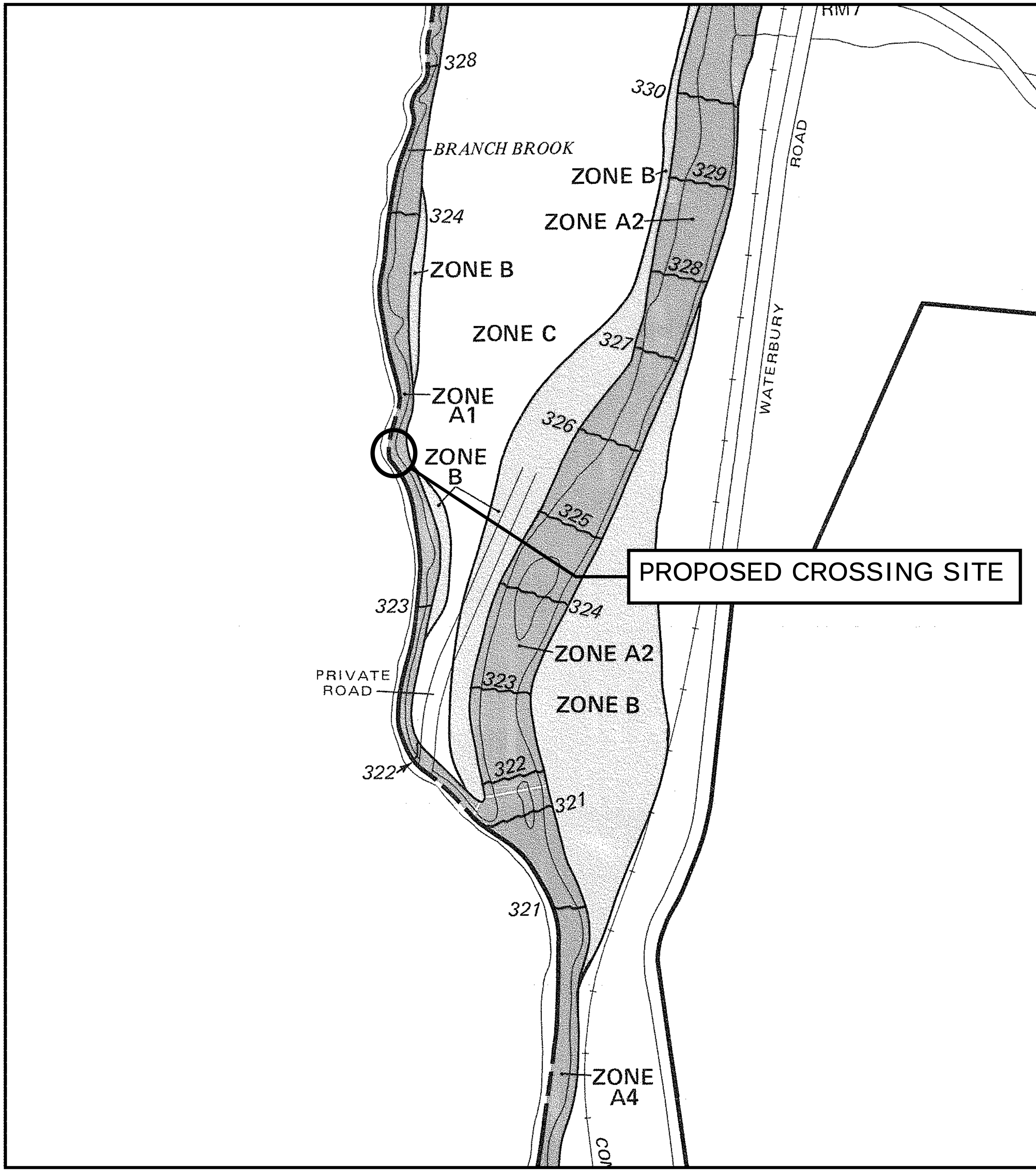


BL Companies	NAUGATUCK RIVER GREENWAY OVER BRANCH BROOK TOWNS OF WATERTOWN & THOMASTON, CONNECTICUT	WATERSHED BOUNDARY MAP	BR. NO.:
			PROJ. NO.: 1800579
			SCALE: 1" = 6,000'



NAUGATUCK RIVER GREENWAY OVER BRANCH BROOK TOWNS OF WATERTOWN & THOMASTON, CONNECTICUT	SURFICIAL MATERIALS MAP	BR. NO.:
		PROJ. NO.: 1800579
		SCALE: 1" = 6,000'

BL Companies



APPROXIMATE SCALE

400 0 400 FEET

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

TOWN OF
THOMASTON,
CONNECTICUT
LITCHFIELD COUNTY

PANEL 5 OF 6
(SEE MAP INDEX FOR PANELS NOT PRINTED)

COMMUNITY-PANEL NUMBER
090055 0005 B

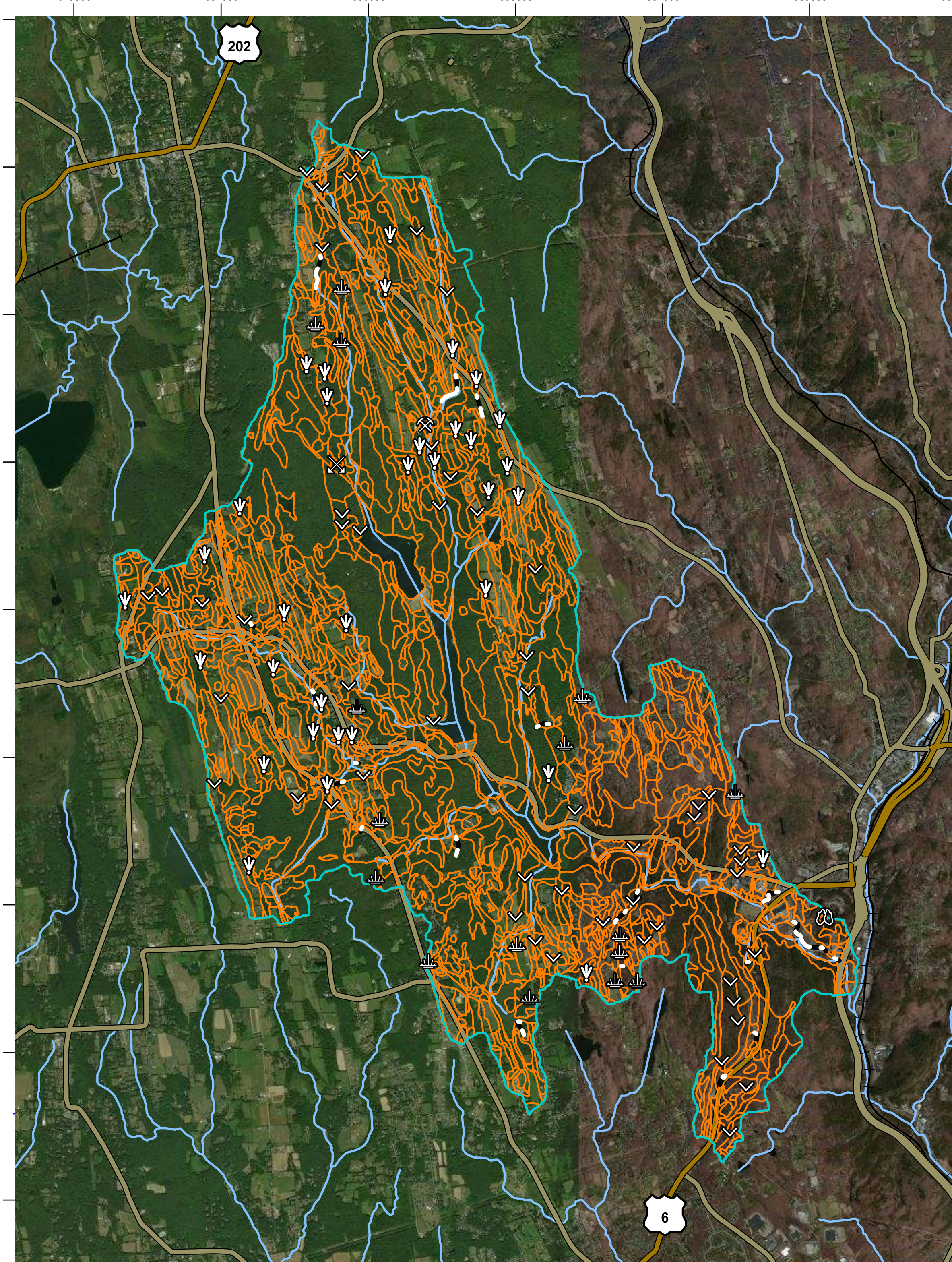
EFFECTIVE DATE:
JULY 5, 1982

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

APPENDIX A: WEB SOIL SURVEY DATA

Soil Map



Map Scale: 1:82,700 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 1000, 2000, 4000, 6000

Feet: 0, 4000, 8000, 16000, 24000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: State of Connecticut
Survey Area Data: Version 19, Sep 13, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 28, 2011—Oct 5, 2016

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
2	Ridgebury fine sandy loam, 0 to 3 percent slopes	126.3	0.9%
3	Ridgebury, Leicester, and Whitman soils, 0 to 8 percent slopes, extremely stony	727.8	5.0%
4	Leicester fine sandy loam	23.2	0.2%
12	Raypol silt loam	9.0	0.1%
13	Walpole sandy loam, 0 to 3 percent slopes	16.5	0.1%
15	Scarboro muck, 0 to 3 percent slopes	22.1	0.2%
16	Halsey silt loam	42.4	0.3%
17	Timakwa and Natchaug soils, 0 to 2 percent slopes	11.6	0.1%
18	Catden and Freetown soils, 0 to 2 percent slopes	160.1	1.1%
30B	Branford silt loam, 3 to 8 percent slopes	12.3	0.1%
34A	Merrimac fine sandy loam, 0 to 3 percent slopes	13.8	0.1%
34B	Merrimac fine sandy loam, 3 to 8 percent slopes	122.0	0.8%
34C	Merrimac fine sandy loam, 8 to 15 percent slopes	46.3	0.3%
38A	Hinckley loamy sand, 0 to 3 percent slopes	25.2	0.2%
38C	Hinckley loamy sand, 3 to 15 percent slopes	162.5	1.1%
38E	Hinckley loamy sand, 15 to 45 percent slopes	22.3	0.2%
45A	Woodbridge fine sandy loam, 0 to 3 percent slopes	44.8	0.3%
45B	Woodbridge fine sandy loam, 3 to 8 percent slopes	431.2	3.0%
45C	Woodbridge fine sandy loam, 8 to 15 percent slopes	55.2	0.4%
46B	Woodbridge fine sandy loam, 0 to 8 percent slopes, very stony	87.5	0.6%
46C	Woodbridge fine sandy loam, 8 to 15 percent slopes, very stony	17.4	0.1%
47C	Woodbridge fine sandy loam, 3 to 15 percent slopes, extremely stony	549.8	3.8%

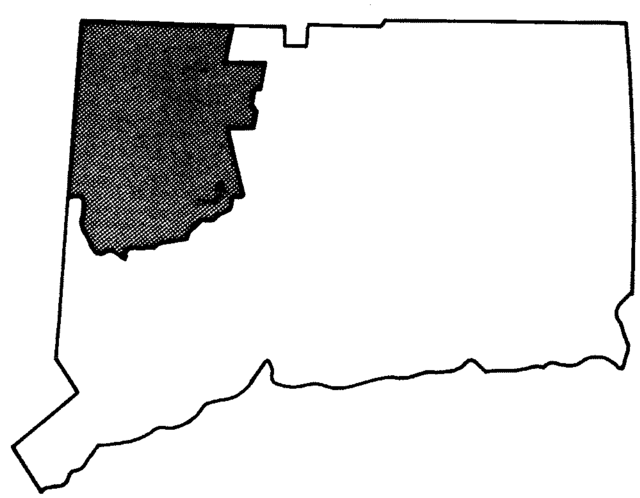
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
50A	Sutton fine sandy loam, 0 to 3 percent slopes	9.2	0.1%
50B	Sutton fine sandy loam, 3 to 8 percent slopes	29.8	0.2%
51B	Sutton fine sandy loam, 0 to 8 percent slopes, very stony	23.6	0.2%
52C	Sutton fine sandy loam, 2 to 15 percent slopes, extremely stony	77.7	0.5%
57C	Gloucester gravelly sandy loam, 8 to 15 percent slopes	0.2	0.0%
59C	Gloucester gravelly sandy loam, 3 to 15 percent slopes, extremely stony	29.1	0.2%
59D	Gloucester gravelly sandy loam, 15 to 35 percent slopes, extremely stony	17.2	0.1%
60B	Canton and Charlton fine sandy loams, 3 to 8 percent slopes	396.4	2.7%
60C	Canton and Charlton fine sandy loams, 8 to 15 percent slopes	193.8	1.3%
60D	Canton and Charlton soils, 15 to 25 percent slopes	49.9	0.3%
61B	Canton and Charlton fine sandy loams, 0 to 8 percent slopes, very stony	95.8	0.7%
61C	Canton and Charlton fine sandy loams, 8 to 15 percent slopes, very stony	70.0	0.5%
62C	Canton and Charlton fine sandy loams, 3 to 15 percent slopes, extremely stony	245.5	1.7%
62D	Canton and Charlton fine sandy loams, 15 to 35 percent slopes, extremely stony	168.1	1.2%
73C	Charlton-Chatfield complex, 0 to 15 percent slopes, very rocky	1,095.9	7.6%
73E	Charlton-Chatfield complex, 15 to 45 percent slopes, very rocky	221.1	1.5%
75C	Hollis-Chatfield-Rock outcrop complex, 3 to 15 percent slopes	2,329.2	16.1%
75E	Hollis-Chatfield-Rock outcrop complex, 15 to 45 percent slopes	1,623.2	11.2%
76E	Rock outcrop-Hollis complex, 3 to 45 percent slopes	309.2	2.1%
76F	Rock outcrop-Hollis complex, 45 to 60 percent slopes	92.8	0.6%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
84B	Paxton and Montauk fine sandy loams, 3 to 8 percent slopes	1,590.5	11.0%
84C	Paxton and Montauk fine sandy loams, 8 to 15 percent slopes	1,000.4	6.9%
84D	Paxton and Montauk fine sandy loams, 15 to 25 percent slopes	224.3	1.5%
85B	Paxton and Montauk fine sandy loams, 3 to 8 percent slopes, very stony	156.5	1.1%
85C	Paxton and Montauk fine sandy loams, 8 to 15 percent slopes, very stony	247.6	1.7%
86C	Paxton and Montauk fine sandy loams, 3 to 15 percent slopes, extremely stony	165.4	1.1%
86D	Paxton and Montauk fine sandy loams, 15 to 35 percent slopes, extremely stony	359.5	2.5%
100	Suncook loamy fine sand	2.9	0.0%
101	Occum fine sandy loam	66.1	0.5%
102	Pootatuck fine sandy loam	8.8	0.1%
107	Limerick and Lim soils	1.6	0.0%
108	Saco silt loam	16.1	0.1%
109	Fluvaquents-Udifluvents complex, frequently flooded	26.4	0.2%
301	Beaches-Udipsamments complex, coastal	1.1	0.0%
306	Udorthents-Urban land complex	107.7	0.7%
307	Urban land	14.7	0.1%
308	Udorthents, smoothed	112.5	0.8%
309	Udorthents, flood control	49.6	0.3%
702A	Tisbury silt loam, 0 to 3 percent slopes	12.1	0.1%
702B	Tisbury silt loam, 3 to 8 percent slopes	3.3	0.0%
703B	Haven silt loam, 3 to 8 percent slopes	10.2	0.1%
703C	Haven silt loam, 8 to 15 percent slopes	2.4	0.0%
W	Water	488.6	3.4%
Totals for Area of Interest		**14,475.5**	**100.0%**

APPENDIX B: FEMA FLOOD INSURANCE STUDY

FLOOD INSURANCE STUDY

TOWN OF WATERTOWN, CONNECTICUT
LITCHFIELD COUNTY



MAY 1980

federal emergency management agency
federal insurance administration

COMMUNITY NUMBER - 090058

The population of Watertown has increased steadily from 3,100 in 1900 to 18,610 in 1970. This population growth is a reflection of the change in Watertown from rural and agricultural in character to urban and suburban. Thirty percent of the town's land area, however, is still used for agricultural purposes. A modern superhighway system, which connects Watertown to the City of Waterbury, reducing commuting time, encourages suburban development.

Residential development in Watertown, as a whole, consists mainly of single- family detached houses. The most developed portion of the town's land area is arranged in a land use pattern consisting of an elongated urban core surrounded by suburban areas, that extend northwestward into rural countryside.

Watertown has only a small supply of easily developable land available. Much of the land presents problems for urban development because of uneven topography and less than ideal subsoil conditions.

The climate in Watertown is variable, with the average annual precipitation ranging between 44 and 52 inches. Temperatures in the area range from below 0 degrees Fahrenheit (°F) to greater than 100°F, with an annual average of approximately 50°F.

2.3 Principal Flood Problems

Numerous damaging floods have occurred in the Naugatuck River basin which have affected the Town of Watertown. Floods causing significant damage in this century occurred in 1927, 1936, 1938, 1948 and 1955.

The August, 1955 flood was the greatest flood ever recorded in the Naugatuck River basin with peak discharges three to four times the magnitude of any other flood. Between August 11-15, Hurricane Connie brought 4 to 8 inches of rainfall to the basin. Due to the unusually dry antecedent conditions, very little runoff resulted from this storm. However, when Hurricane Diane deposited 10 to 13 inches of rainfall in 24 hours, runoff of major proportions occurred due to the saturated condition of the soil. The failure of many dams and bridges contributed substantially to peak discharges. Downstream of the Thomaston Dam, the Naugatuck River claimed 36 lives and caused an estimated loss of nearly 193,000,000 dollars. Over 80 percent of this loss occurred in Waterbury, Watertown, Naugatuck and Ansonia.

High-water mark data were recorded at 332.5, 326.4, 314.9 and 309.9 feet, for the Naugatuck River at the mouth of Jericho Brook, at the mouth of Nibbling Brook, at Frost Bridge, and 0.1 mile below Frost Bridge, respectively.

Major floods occurred in the upper Naugatuck River basin in November 1927, March 1936, September 1938, December 1948, August 1955, and October 1955. With the exception of the August 1955 flood, the peak discharges of the other events generally ranged from 15,000 to 20,000 cubic feet per second (cfs) in the Naugatuck River at Waterbury, with estimated frequencies ranging from approximately 15 to 30 years. The August 1955 event was the greatest flood of record, by far, with a flow in the Naugatuck River at Waterbury of 90,000 cfs, with a corresponding frequency considered in excess of 100 years. The peak discharge on Branch Brook in 1955 was estimated at 10,300 cfs, approximately equal to the Leadmine Brook peak flow of 10,400 cfs.

In addition to the Naugatuck River, Steele Brook also has a history of damaging floods, the most serious of which occurred in August 1955. Areas close to the brook are susceptible to intense and sudden floods as a result of the steep sloping streets and terrain of the basin. The floodwaters converge from the fan-shaped drainage area and due to the limited natural storage in the upper basin, quickly exceed the channel capacity and overflow into the flood plain. Additionally, numerous restrictions such as low bridges, overhanging buildings, private dams and sharp bends in the channel all contribute to the flooding problems. In June 1973, and again in July 1975, Steele Brook overflowed its banks and resulted in extensive damage to commercial and manufacturing properties, homes and town installations.

Since 1955, the COE has constructed a system of reservoirs in the basin which will modify all future floods. In a repeat of historic flood events, the system would generally reduce flows on the Naugatuck River at Waterbury by 60 to 75 percent depending on storm orientation. Black Rock Reservoir on Branch Brook would generally maintain flows to safe channel capacity.

2.4 Flood Protection Measures

Following the devastating flood of 1955 along the Naugatuck River, the COE completed seven flood control dams and reservoirs in the Naugatuck River basin. Four of these, namely Thomaston, Hancock Brook, Black Rock and Northfield Brook, provided protection to the Town of Watertown.

was developed between the log of the 2-year flood and the drainage area and it was found that for New England, discharges vary in accordance with the drainage area raised to the exponent power of 0.70.

There are no discharge records for Branch Brook. In 1970, the COE completed Black Rock Dam, located on Branch Brook about two miles above the mouth. Discharges from the dam are controlled by gate operations. The anticipated releases for the 10- and 50-year events would probably not exceed the nondamaging downstream channel capacity and these releases would not be made until downstream flood conditions subsided. The 100- and 500-year discharges are estimated based on hydrographs of major events routed through the reservoir. On Branch Brook above Wigwam Reservoir, peak discharge frequencies were determined by using relationships based on records for the USGS gaging station on nearby Leadmine Brook and then relating it to the Branch Brook watershed based on a direct drainage area relationship. A regional study was not undertaken to determine the drainage area-discharge relationship for Leadmine and Branch Brooks. However, the runoff characteristics of Leadmine Brook are considered to be similar to those of Branch Brook.

A summary of drainage area-peak discharge relationships is shown in Table 1, "Summary of Discharges."

TABLE 1 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
NAUGATUCK RIVER					
At downstream corporate limits	137	5,300	5,400	8,000	21,600
At upstream corporate limits	131	5,000	5,000	5,200	14,000
BRANCH BROOK					
At mouth	22.8	800	800	900	2,300
At Black Rock Dam	20.4	800	800	900	2,300
At Wigwam Dam	17.5	2,200	5,300	7,600	16,500
STEELE BROOK					
At downstream corporate limits	12.4	1,410	2,740	3,550	6,245
Above Wattles Brook	9.0	1,130	2,200	2,840	5,000
At Hemingway Pond	5.7	820	1,600	2,060	3,600
Below Smith Pond Brook confluence	4.0	640	1,250	1,600	2,800

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH[3] (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Naugatuck River (continued)								
T	20,440[1]	164	1,295	6.2	319.0	319.0	319.3	0.3
U	22,300[1]	118	884	5.7	320.5	320.5	320.6	0.1
Branch Brook								
A	100[2]	81	303	3.0	321.6	321.6	322.6	1.0
B	265[2]	88	469	1.9	322.0	322.0	322.8	0.8
C	1,700[2]	132	149	6.1	324.2	324.2	324.2	0.0
D	2,400[2]	46	146	6.2	330.0	330.0	330.0	0.0
E	2,600[2]	43	102	8.8	331.1	331.1	331.1	0.0
F	3,590[2]	68	186	4.8	338.1	338.1	338.1	0.0
G	5,410[2]	70	123	7.3	349.0	349.0	349.0	0.0
H	6,320[2]	72	218	4.1	353.6	353.6	353.7	0.1
I	7,130[2]	78	143	6.3	356.7	356.7	356.8	0.1
J	7,290[2]	54	119	7.6	357.5	357.5	357.5	0.0
K	8,400[2]	38	141	6.4	365.2	365.2	365.2	0.0
L	10,000[2]	31	92	9.8	381.9	381.9	381.9	0.0
M	20,500[2]	1,536	32,010	0.2	567.4	567.4	568.0	0.6
N	24,270[2]	370	4,953	1.5	567.4	567.4	568.0	0.6
O	24,670[2]	914	11,814	0.6	569.3	569.3	569.3	0.0

[1]Feet above corporate limits
[2]Feet above confluence with Naugatuck River
[3]This width extends beyond corporate limits

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWN OF WATERTOWN, CT
(LITCHFIELD CO.)

FLOODWAY DATA

NAUGATUCK RIVER AND BRANCH BROOK

TABLE 2

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
Naugatuck River							
Reach 1	03	-1.7	-1.6	+6.1	015	A3	Varies
Reach 2	02,03	-2.0	-1.9	+7.6	020	A4	Varies
Branch Brook							
Reach 1	01,02	-0.6	-0.3	+1.7	005	A1	Varies
Reach 2	04	-3.6	-1.7	+3.5	035	A7	Varies
Steele Brook							
Reach 1	06	-2.6	-0.8	+2.2	025	A5	Varies
Reach 2	06	-4.0	-1.4	+0.9	040	A8	Varies
Reach 3	06	-2.1	-0.5	+1.2	020	A4	Varies
Reach 4	06	-2.3	-0.7	+1.8	025	A5	Varies
Reach 5	06	-4.8	-1.5	+1.4	050	A10	Varies
Reach 6	06	-7.5	-4.1	+5.6	075	A15	Varies
Reach 7	05,06	-1.8	-0.6	+2.2	020	A4	Varies
Reach 8	05	-2.3	-0.8	+2.3	025	A5	Varies
Reach 9	05	-5.4	-1.9	+5.4	055	A11	Varies
Reach 10	05	-3.0	-1.2	+3.2	030	A6	Varies
Reach 11	05	-1.3	-0.3	+0.9	015	A3	Varies

[1] Flood Insurance Rate Map Panel
[2] Weighted average
[3] Rounded to the nearest foot - see map

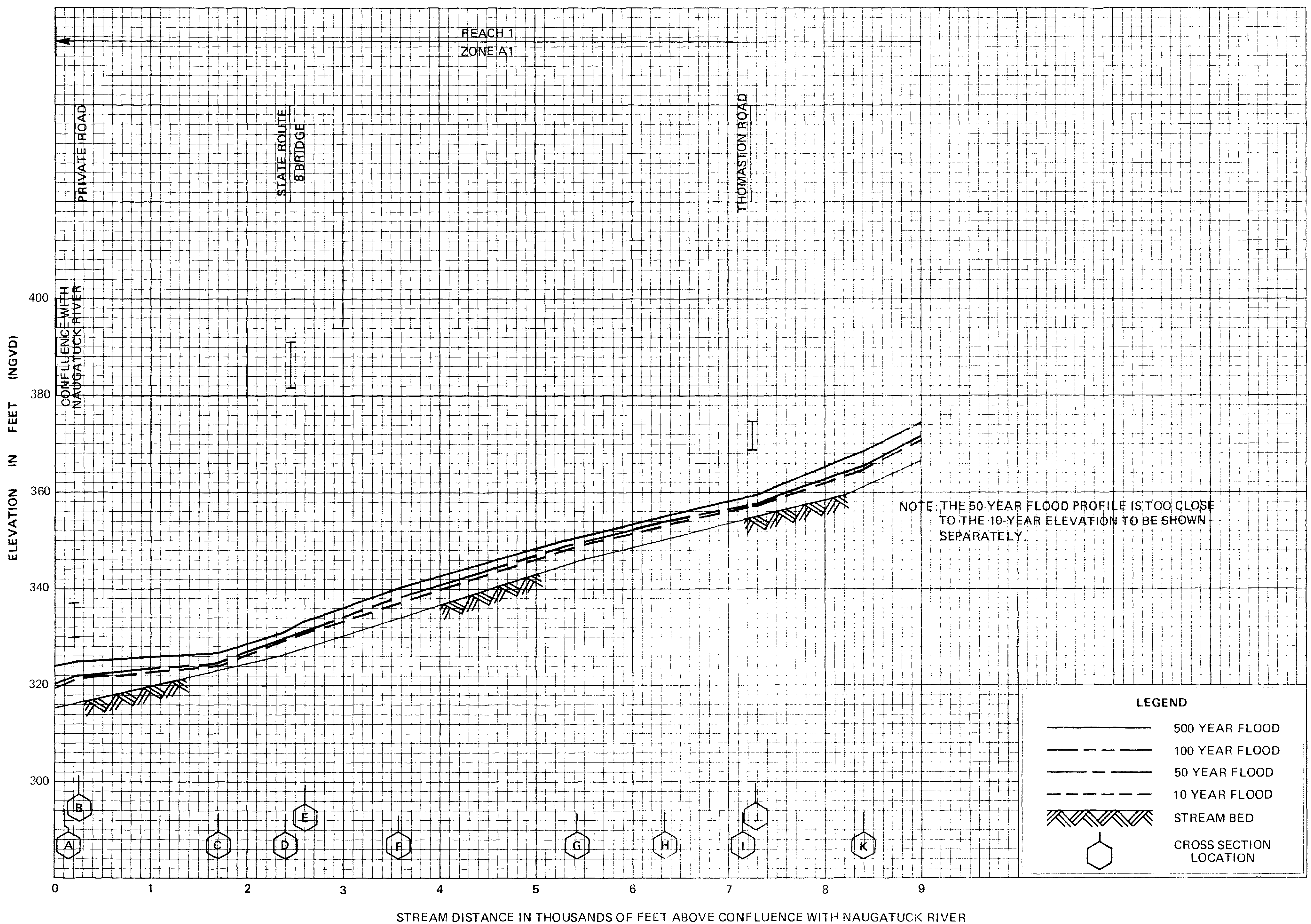
FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWN OF WATERTOWN, CT
(LITCHFIELD CO.)

FLOOD INSURANCE ZONE DATA

NAUGATUCK RIVER, BRANCH BROOK AND STEELE BROOK

TABLE 3



FLOOD PROFILES

BRANCH BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWN OF WATERTOWN, CT
(LITCHFIELD CO.)

03P

APPENDIX C: USGS STREAM GAGE NO. 01208013 – BRANCH BROOK NEAR THOMASTON, CT

StreamStats Data-Collection Station Report

USGS Station Number	**01208013**
Station Name	**BRANCH BROOK NR THOMASTON,CT.**

Click here to link to available data on NWIS-Web for this site.

Descriptive Information

Station Type	Streamgage, continuous record
Location	
Gage	
Regulation and Diversions	
Regulated?	Unknown
Period of Record	1971-2001
Remarks	Peak flows affected by flood control.
Latitude (degrees NAD83)	41.65371
Longitude (degrees NAD83)	-73.09483
Hydrologic unit code	01100005
County	-
HCDN2009	No

Physical Characteristics

Characteristic Name	Value	Units	Citation Number
Descriptive Information			
Datum_of_Latitude_Longitude	NAD83	dimensionless	30
District_Code	09	dimensionless	30
Begin_date_of_record	10/1/1974	days	41
End_date_of_record	5/13/1993	days	41
Number_of_days_of_record	5549	days	41
Number_of_days_GT_0	5549	days	41
Basin Dimensional Characteristics			
Drainage_Area	20.8	square miles	30

Streamflow Statistics

Statistic Name	Value	Units	Citation Number	Preferred?	Years of Record	Standard Error, percent	Variance log-10	Lower 95% Confidence Interval	Upper 95% Confidence Interval	Start Date	End Date	Remarks
Flow-Duration Statistics												
1_Percent_Duration	383.06	cubic feet per second	41	Y	15							
5_Percent_Duration	111	cubic feet per second	41	Y	15							
10_Percent_Duration	68	cubic feet per second	41	Y	15							
20_Percent_Duration	43	cubic feet per	41	Y	15							

		second			
25_Percent_Duration	37	cubic feet per second	41	Y	15
30_Percent_Duration	32	cubic feet per second	41	Y	15
40_Percent_Duration	23	cubic feet per second	41	Y	15
50_Percent_Duration	18	cubic feet per second	41	Y	15
60_Percent_Duration	13	cubic feet per second	41	Y	15
70_Percent_Duration	9.92	cubic feet per second	41	Y	15
75_Percent_Duration	8.3	cubic feet per second	41	Y	15
80_Percent_Duration	7.03	cubic feet per second	41	Y	15
90_Percent_Duration	3.6	cubic feet per second	41	Y	15
95_Percent_Duration	1.5	cubic feet per second	41	Y	15
99_Percent_Duration	0.41	cubic feet per second	41	Y	15
General Flow Statistics					
Minimum_daily_flow	0.18	cubic feet per second	41	Y	15
Maximum_daily_flow	713	cubic feet per second	41	Y	15
Std_Dev_of_daily_flows	63.769	cubic feet per second	41	Y	15
Average_daily_streamflow	34.999	cubic feet per second	41	Y	15
Base Flow Statistics					
Number_of_years_to_compute_BFI	15	years	42	Y	
Average_BFI_value	0.395	dimensionless	42	Y	
Std_dev_of_annual_BFI_values	0.112	dimensionless	42	Y	

Citations

Citation Number	*Citation Name and URL*
30	Imported from NWIS file
41	Wolock, D.M., 2003, Flow characteristics at U.S. Geological Survey streamgages in the conterminous United States: U.S. Geological Survey Open-File Report 03-146, digital data set
42	Wolock, D.M., 2003, Base-flow index grid for the conterminous United States: U.S. Geological Survey Open-File Report 03-263, digital data set

APPENDIX D: PEAKFQ FLOWS – BRANCH BROOK NEAR THOMASTON, CT

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY            Seq.002.000
  Version 7.2        Annual peak flow frequency analysis      Run Date / Time
  3/28/2018                                                    10/09/2019 11:00

                         --- PROCESSING OPTIONS ---

                     Plot option         = Graphics device
                     Basin char output   = None
                     Print option        = Yes
                     Debug print         = No
                     Input peaks listing = Long
                     Input peaks format  = WATSTORE peak file

                     Input files used:
                        peaks (ascii)  -
G:\JOBS18\04\1800579\ENG-TECH\TRANS\Hydra\Hydrology\PEAK_01208013_TEST.TXT

                        specifications -
G:\JOBS18\04\1800579\ENG-TECH\TRANS\Hydra\Hydrology\PKFQWPSF.TMP

                     Output file(s):
                        main -
G:\JOBS18\04\1800579\ENG-TECH\TRANS\Hydra\Hydrology\PEAK_01208013_TEST.PRT



  ***  User responsible for assessment and interpretation of the following analysis
 ***

1


  Program PeakFq           U. S. GEOLOGICAL SURVEY            Seq.001.001
  Version 7.2        Annual peak flow frequency analysis      Run Date / Time
  3/28/2018                                                    10/09/2019 11:00

              Station - 01208013  BRANCH BROOK NEAR THOMASTON, CT


                     TABLE 1 - INPUT DATA SUMMARY

                Number of peaks in record           =       25
                Peaks not used in analysis          =        0
                Gaged peaks in analysis             =       25
                Historic peaks in analysis          =        0
                Beginning Year                      =     1971
                Ending Year                         =     1995
                Historical Period Length            =       25
                Skew option                         =   WEIGHTED
```

```
        Regional skew                         =    0.340
             Standard error                   =    0.510
             Mean Square error                =    0.260
        Gage base discharge                   =      0.0
        User supplied high outlier threshold =   --
        User supplied PILF (LO) criterion    =   --
        Plotting position parameter          =     0.00
        Type of analysis                               EMA
        PILF (LO) Test Method                         MGBT
        Perceptible Ranges:
            Start Year  End Year  Lower Bound  Upper Bound
                  1971      1995          0.0          INF    DEFAULT

        Interval Data                     =   None Specified
```

TABLE 2 - DIAGNOSTIC MESSAGE AND PILF RESULTS

```
WCF002J-CALCS COMPLETED.  RETURN CODE =  2
EMA002W-CONFIDENCE INTERVALS ARE NOT EXACT IF HISTORIC PERIOD > 0
```

MULTIPLE GRUBBS-BECK TEST RESULTS

```
MULTIPLE GRUBBS-BECK PILF THRESHOLD   494.0
NUMBER OF PILFS IDENTIFIED                8
    CLASSIFICATION OF PILFS:
        NUMBER OF ZERO FLOWS              0
        NUMBER OF CENSORED FLOWS          0
        NUMBER OF GAGED PEAKS             8
            GAGED PEAKS AND CORRESPONDING P-VALUES
                   145.0    (0.1052)
                   145.0    (0.0011)
                   288.0    (0.2320)
                   288.0    (0.0440)
                   308.0    (0.0155)
                   332.0    (0.0057)
                   355.0    (0.0014)
                   390.0    (0.0007)
```

```
                   Kendall's Tau Parameters

                                    MEDIAN   No. of
                   TAU    P-VALUE    SLOPE   PEAKS
           ---------------------------------------
```

GAGED PEAKS   -0.180   0.216   -9.982   25

1

Program PeakFq   U. S. GEOLOGICAL SURVEY   Seq.001.002
Version 7.2   Annual peak flow frequency analysis   Run Date / Time
3/28/2018   10/09/2019 11:00

Station - 01208013 BRANCH BROOK NEAR THOMASTON, CT

TABLE 3 - ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	LOGARITHMIC		
	MEAN	STANDARD DEVIATION	SKEW
EMA WITHOUT REG SKEW	2.7402	0.1189	-0.423
EMA WITH REG SKEW	2.7476	0.1062	0.134

EMA ESTIMATE OF MSE OF SKEW WITHOUT REG SKEW 0.2364
EMA ESTIMATE OF MSE OF SKEW W/GAGED PEAKS ONLY (AT-SITE) 0.2364

TABLE 4 - ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL	<- EMA ESTIMATE ->		<- FOR EMA ESTIMATE WITH REG SKEW ->		
EXCEEDANCE	WITH	WITHOUT	LOG VARIANCE	<-CONFIDENCE LIMITS->	
PROBABILITY	REG SKEW	REG SKEW	OF EST.	5% LOWER	95% UPPER
0.9950	307.2	243.7	0.0090	128.0	396.4
0.9900	324.4	267.4	0.0071	149.3	405.1
0.9500	377.6	339.9	0.0035	220.4	437.3
0.9000	410.3	383.2	0.0023	265.1	460.9
0.8000	454.6	439.9	0.0013	322.0	497.5
0.6667	501.2	496.9	0.0008	372.6	543.0
0.5000	556.3	560.5	0.0005	429.3	609.3
0.4292	581.1	588.0	0.0005	492.1	643.8
0.2000	685.9	695.0	0.0006	620.8	798.7
0.1000	767.7	769.6	0.0009	684.7	941.4
0.0400	867.7	851.5	0.0015	755.6	1160.0
0.0200	940.4	905.3	0.0021	803.9	1349.0
0.0100	1012.	954.0	0.0028	848.9	1559.0
0.0050	1083.	998.7	0.0035	891.1	1791.0
0.0020	1177.	1053.	0.0047	943.3	2136.0

*Note: If Station Skew option is selected then EMA ESTIMATE WITH REG SKEW will display values for and be equal to EMA ESTIMATE WITHOUT REG SKEW.

1

Station - 01208013 BRANCH BROOK NEAR THOMASTON, CT

TABLE 5 - INPUT DATA LISTING

WATER YEAR	PEAK VALUE	PEAKFQ CODES	FLOW INTERVALS (WHERE LOWER BOUND NOT = UPPER BOUND) LOWER BOUND	UPPER BOUND	REMARKS
1971	494.0	K			
1972	390.0	K			
1973	585.0	K			
1974	555.0	K			
1975	795.0	K			
1976	590.0	K			
1977	500.0	K			
1978	705.0	K			
1979	750.0	K			
1980	145.0	K			
1981	725.0	K			
1982	805.0	K			
1983	755.0	K			
1984	683.0	K			
1985	308.0	K			
1986	538.0	K			
1987	766.0	K			
1988	145.0	K			
1989	604.0	K			
1990	539.0	K			
1991	573.0	K			
1992	288.0	K			
1993	355.0	K			
1994	288.0	K			
1995	332.0	K			

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS CODE	DEFINITION

```
D        3    Dam failure, non-recurrent flow anomaly
G        8    Discharge greater than stated value
X       3+8   Both of the above
L        4    Discharge less than stated value
K     6 OR C  Known effect of regulation or urbanization
H        7    Historic peak

-  Minus-flagged discharge -- Not used in computation
      -8888.0 -- No discharge value given
-  Minus-flagged water year -- Historic peak used in computation
```

1

```
Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.004
Version 7.2         Annual peak flow frequency analysis      Run Date / Time
3/28/2018                                                     10/09/2019 11:00

            Station - 01208013  BRANCH BROOK NEAR THOMASTON, CT
```

TABLE 6 - EMPIRICAL FREQUENCY CURVES -- HIRSCH-STEDINGER PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	EMA ESTIMATE	FLOW INTERVALS (WHERE LOWER BOUND NOT = UPPER BOUND) LOWER BOUND	UPPER BOUND
1982	805.0	0.0383		
1975	795.0	0.0768		
1987	766.0	0.1152		
1983	755.0	0.1537		
1979	750.0	0.1922		
1981	725.0	0.2307		
1978	705.0	0.2691		
1984	683.0	0.3076		
1989	604.0	0.3461		
1976	590.0	0.3846		
1973	585.0	0.4230		
1991	573.0	0.4615		
1974	555.0	0.5000		
1990	539.0	0.5385		
1986	538.0	0.5770		
1977	500.0	0.6154		
1971	494.0	0.6539		
* 1972	390.0	0.6924		
* 1993	355.0	0.7309		
* 1995	332.0	0.7693		
* 1985	308.0	0.8078		
* 1992	288.0	0.8848		

```
  * 1994      288.0     0.8463
  * 1980      145.0     0.9617
  * 1988      145.0     0.9232

    * DENOTES PILF (LO)

1


  Program PeakFq           U. S. GEOLOGICAL SURVEY           Seq.001.005
  Version 7.2        Annual peak flow frequency analysis      Run Date / Time
  3/28/2018                                                   10/09/2019 11:00

              Station - 01208013  BRANCH BROOK NEAR THOMASTON, CT


                    TABLE 7 - EMA REPRESENTATION OF DATA

                                                   <---- USER-ENTERED
---->&lt;-------- FINAL ------->
  WATER <----- OBSERVED ----><-------- EMA -------><- PERCEPTIBLE RANGES -><-
PERCEPTIBLE RANGES ->
   YEAR    Q_LOWER    Q_UPPER    Q_LOWER    Q_UPPER       LOWER       UPPER
LOWER       UPPER
   1971      494.0      494.0      494.0      494.0         0.0         INF
494.0        INF
   1972      390.0      390.0        0.0      494.0         0.0         INF
494.0        INF
   1973      585.0      585.0      585.0      585.0         0.0         INF
494.0        INF
   1974      555.0      555.0      555.0      555.0         0.0         INF
494.0        INF
   1975      795.0      795.0      795.0      795.0         0.0         INF
494.0        INF
   1976      590.0      590.0      590.0      590.0         0.0         INF
494.0        INF
   1977      500.0      500.0      500.0      500.0         0.0         INF
494.0        INF
   1978      705.0      705.0      705.0      705.0         0.0         INF
494.0        INF
   1979      750.0      750.0      750.0      750.0         0.0         INF
494.0        INF
   1980      145.0      145.0        0.0      494.0         0.0         INF
494.0        INF
   1981      725.0      725.0      725.0      725.0         0.0         INF
494.0        INF
   1982      805.0      805.0      805.0      805.0         0.0         INF
494.0        INF
   1983      755.0      755.0      755.0      755.0         0.0         INF
494.0        INF
```

```
   1984      683.0      683.0      683.0      683.0          0.0         INF
494.0        INF
   1985      308.0      308.0        0.0      494.0          0.0         INF
494.0        INF
   1986      538.0      538.0      538.0      538.0          0.0         INF
494.0        INF
   1987      766.0      766.0      766.0      766.0          0.0         INF
494.0        INF
   1988      145.0      145.0        0.0      494.0          0.0         INF
494.0        INF
   1989      604.0      604.0      604.0      604.0          0.0         INF
494.0        INF
   1990      539.0      539.0      539.0      539.0          0.0         INF
494.0        INF
   1991      573.0      573.0      573.0      573.0          0.0         INF
494.0        INF
   1992      288.0      288.0        0.0      494.0          0.0         INF
494.0        INF
   1993      355.0      355.0        0.0      494.0          0.0         INF
494.0        INF
   1994      288.0      288.0        0.0      494.0          0.0         INF
494.0        INF
   1995      332.0      332.0        0.0      494.0          0.0         INF
494.0        INF
1


 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      25


Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  01208013       USGS BRANCH BROOK NEAR THOMASTON,


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

APPENDIX E: SUPPLEMENTARY REFERENCE DATA

- CTDOT Drainage Manual Transfer Calculations
- StreamStats Computation at Bridge Site
- NOAA Atlas 14 Data
- USGS Reference Publications

6.11 Transferring Gaged Data

6.11.1 Procedure

Gaged data can be transferred up or downstream on the gaged stream only. If the drainage area for the location of concern is ≥ 75% and ≤ 125% of the drainage area at the gage, then the gaged data can be transferred with equation 6.12.

6.11.2 Transfer Equation

The following equation shall be used to transfer gage data:

$$\frac{Q_1 / A_1}{Q_2 / A_2} = \frac{A_1^{[(0.894 / A_1^{0.048})-1]}}{A_2^{[(0.894 / A_2^{0.048})-1]}}$$

(English only)

(6.12)

Q_1 and A_1 represent the discharge rate and watershed area at one point in the watershed and Q_2 and A_2 represent the rate and area at the gage or known outlet which remain constant while Q_1 and A_1 are varied.

Q = discharge in cubic feet per second
A = drainage area in square miles

Source: Adopted from Mockus, V., SCS National Engineering Handbook, Section 4, Hydrology, 1972

Transfer Equation From DOT Drainage Manual

Prepared By: BGR Date: 10/9/2019
Checked By: DMC Date: 10/11/2019

A1 = 22.6 sq mi **Proposed Drain. Area**
A2 = 20.8 sq mi **Gage Drain. Area**

***PeakFQ trans. to Bridge**

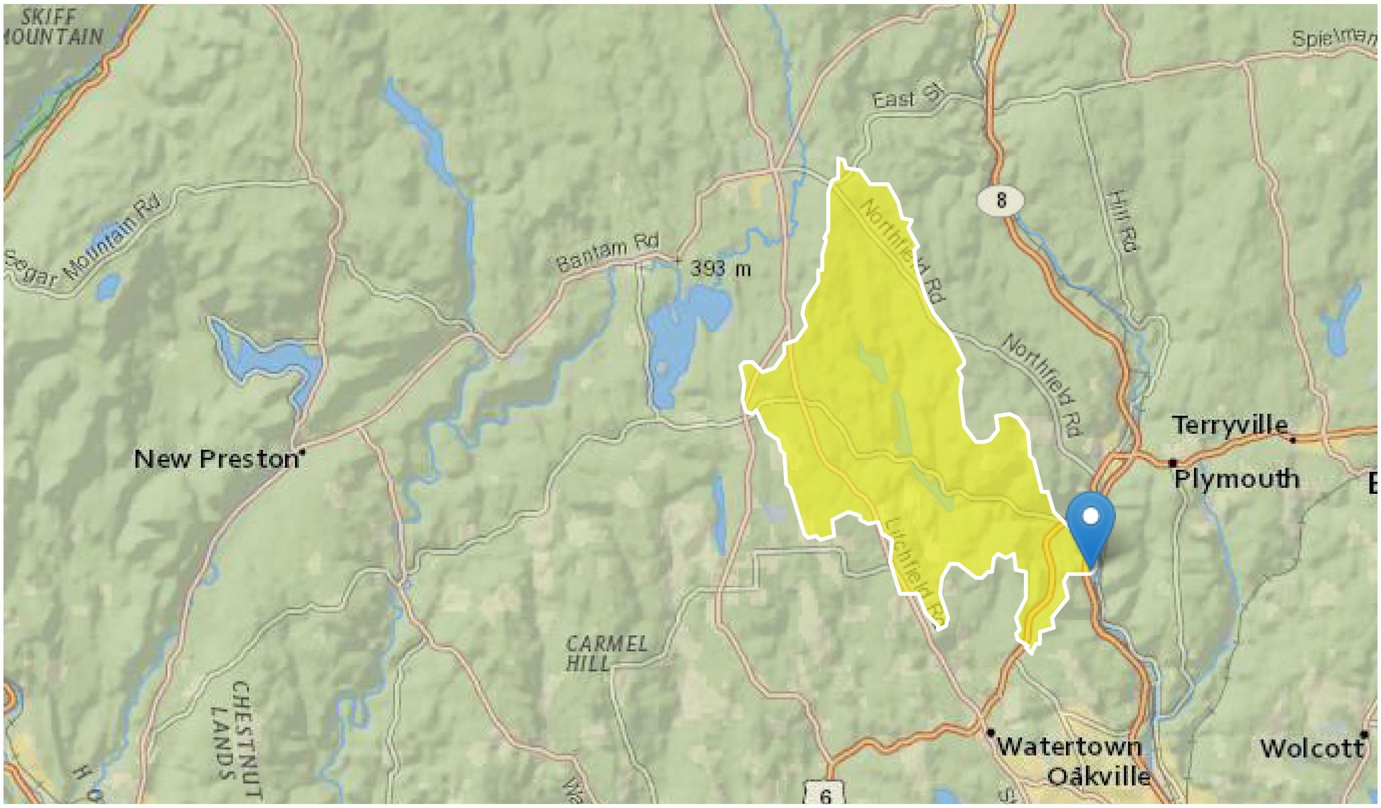
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
Q2 =	556.3	685.9	767.7	867.7	940.4	1012	1177

***Site Flows**

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
Q1 =	587	724	811	916	993	1069	1243

StreamStats Report

Region ID: CT
Workspace ID: CT20191009150317053000
Clicked Point (Latitude, Longitude): 41.64395, -73.08096
Time: 2019-10-09 11:03:33 -0400



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	22.6	square miles
I24H2Y	Maximum 24-hour precipitation that occurs on average once in 2 years - Equivalent to precipitation intensity index	3.391	inches
ELEV	Mean Basin Elevation	859	feet
I24H10Y	Maximum 24-hour precipitation that occurs on average once in 10 years	4.807	inches
I24H25Y	Maximum 24-hour precipitation that occurs on average once in 25 years	5.867	inches

Parameter Code	Parameter Description	Value	Unit
I24H50Y	Maximum 24-hour precipitation that occurs on average once in 50 years	6.835	inches
I24H100Y	Maximum 24-hour precipitation that occurs on average once in 100 years	7.957	inches
CRSDFT	Percentage of area of coarse-grained stratified drift	2.21	percent
NOVAVPRE	Mean November Precipitation	4.5	inches
PRCWINTER	Mean annual precipitation for December through February	3.8	inches
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	9.69	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	1.59	percent
MAPM	Mean Annual Precip Basin Average	51.543	inches
SGSL	Total stream length intersecting sand and gravel deposits (in miles)	6.57	miles
SOILPERM	Average Soil Permeability	2.941	inches per hour
STRMTOT	total length of all mapped streams (1:24,000-scale) in the basin	68.4	miles
WETLAND	Percentage of Wetlands	1.07	percent

General Disclaimers

The delineation point is in an exclusion area. Warning! Peak flows affected by flood control structures. Peak-flow statistics represent near natural conditions or conditions prior to flood-control.

Peak-Flow Statistics Parameters[Statewide Multiparameter]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	22.6	square miles	1.69	715
I24H2Y	24 Hour 2 Year Precipitation	3.391	inches	2.95	3.82

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
ELEV	Mean Basin Elevation	859	feet	169	1310
I24H10Y	24 Hour 10 Year Precipitation	4.807	inches	4.15	5.53
I24H25Y	24 Hour 25 Year Precipitation	5.867	inches	4.93	7
I24H50Y	24 Hour 50 Year Precipitation	6.835	inches	5.62	8.36
I24H100Y	24 Hour 100 Year Precipitation	7.957	inches	6.41	9.99

Peak-Flow Statistics Flow Report[Statewide Multiparameter]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SE	SEp	Equiv. Yrs.
2 Year Peak Flood	776	ft^3/s	31.8	31.8	3.5
10 Year Peak Flood	1640	ft^3/s	32.7	32.7	8.1
25 Year Peak Flood	2170	ft^3/s	34.4	34.4	10.9
50 Year Peak Flood	2630	ft^3/s	35.9	35.9	12.7
100 Year Peak Flood	3130	ft^3/s	37.6	37.6	14.3
500 Year Peak Flood	4980	ft^3/s	45	45	14.9

Peak-Flow Statistics Citations

Ahearn, E.A.,2004, Regression Equations for Estimating Flood Flows for the 2-, 10-, 25-, 50-, 100-, and 500-Year Recurrence Intervals in Connecticut: U.S. Geological Survey SRI 2004-5160, 62 p. (http://water.usgs.gov/pubs/sir/2004/5160/)

November Flow-Duration Statistics Parameters[Duration Flow 2010 5052]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	22.6	square miles	0.92	150
NOVAVPRE	Mean November Precipitation	4.5	inches	3.48	4.93
CRSDFT	Percent Coarse Stratified Drift	2.21	percent	0.1	55.1

November Flow-Duration Statistics Flow Report[Duration Flow 2010 5052]

Statistic	Value	Unit

Statistic	Value	Unit
November 25 Percent Duration	45.8	ft^3/s
November 50 Percent Duration	24.5	ft^3/s
November 75 Percent Duration	12.4	ft^3/s
November 90 Percent Duration	5.35	ft^3/s
November 99 Percent Duration	1.91	ft^3/s

November Flow-Duration Statistics Citations

Ahearn, E.A.,2010, Regional regression equations to estimate flow-duration statistics in Connecticut: U. S. Geological Survey Scientific Investigations Report 2010-5052, 45 p. (http://pubs.usgs.gov/sir/2010/5052/)

Seasonal Flow Statistics Parameters[Duration Flow 2010 5052]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	22.6	square miles	0.92	150
PRCWINTER	Mean Annual Winter Precipitation	3.8	inches	3.19	4.4
CRSDFT	Percent Coarse Stratified Drift	2.21	percent	0.1	55.1

Seasonal Flow Statistics Flow Report[Duration Flow 2010 5052]

Statistic	Value	Unit
25 Percent Duration December to February	57.1	ft^3/s
50 Percent Duration December to February	34.1	ft^3/s
75 Percent Duration December to February	20.6	ft^3/s
95 Percent Duration DEC FEB	9.31	ft^3/s
99 Percent Duration December to February	4.88	ft^3/s
25 Percent Duration March to April	96	ft^3/s
50 Percent Duration March to April	61.9	ft^3/s
75 Percent Duration March to April	38.5	ft^3/s
95 Percent Duration March to April	21.4	ft^3/s
99 Percent Duration March to April	14.9	ft^3/s

Statistic	Value	Unit
25 Percent Duration July to October	13.5	ft^3/s
50 Percent Duration July to October	5.53	ft^3/s
75 Percent Duration July to October	2.56	ft^3/s
80 Percent Duration July to October	2.16	ft^3/s
99 Percent Duration July to October	0.378	ft^3/s

Seasonal Flow Statistics Citations

Ahearn, E.A.,2010, Regional regression equations to estimate flow-duration statistics in Connecticut: U. S. Geological Survey Scientific Investigations Report 2010-5052, 45 p. (http://pubs.usgs.gov/sir/2010/5052/)

May Flow-Duration Statistics Parameters[Duration Flow 2010 5052]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	22.6	square miles	0.92	150
CRSDFT	Percent Coarse Stratified Drift	2.21	percent	0.1	55.1

May Flow-Duration Statistics Flow Report[Duration Flow 2010 5052]

Statistic	Value	Unit
May 25 Percent Duration	57.6	ft^3/s
May 50 Percent Duration	35.7	ft^3/s
May 75 Percent Duration	23.4	ft^3/s
May 95 Percent Duration	11.7	ft^3/s
May 99 Percent Duration	7.43	ft^3/s

May Flow-Duration Statistics Citations

Ahearn, E.A.,2010, Regional regression equations to estimate flow-duration statistics in Connecticut: U. S. Geological Survey Scientific Investigations Report 2010-5052, 45 p. (http://pubs.usgs.gov/sir/2010/5052/)

June Flow-Duration Statistics Parameters[Duration Flow 2010 5052]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	22.6	square miles	0.92	150
CRSDFT	Percent Coarse Stratified Drift	2.21	percent	0.1	55.1
WETLAND	Percent Wetlands	1.07	percent	0.3	18.1

June Flow-Duration Statistics Flow Report[Duration Flow 2010 5052]

Statistic	Value	Unit
June 25 Percent Duration	28	ft^3/s
June 50 Percent Duration	13.7	ft^3/s
June 75 Percent Duration	7.12	ft^3/s
June 90 Percent Duration	4.72	ft^3/s
June 99 Percent Duration	2.06	ft^3/s

June Flow-Duration Statistics Citations

Ahearn, E.A.,2010, Regional regression equations to estimate flow-duration statistics in Connecticut: U. S. Geological Survey Scientific Investigations Report 2010-5052, 45 p. (http://pubs.usgs.gov/sir/2010/5052/)

Flow-Duration Statistics Parameters[Duration Flow 2010 5052]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	22.6	square miles	0.92	150
ELEV	Mean Basin Elevation	859	feet	168	1287
CRSDFT	Percent Coarse Stratified Drift	2.21	percent	0.1	55.1

Flow-Duration Statistics Flow Report[Duration Flow 2010 5052]

Statistic	Value	Unit
25 Percent Duration	50.7	ft^3/s
99 Percent Duration	0.576	ft^3/s

Flow-Duration Statistics Citations

Ahearn, E.A.,2010, Regional regression equations to estimate flow-duration statistics in Connecticut: U. S. Geological Survey Scientific Investigations Report 2010-5052, 45 p. (http://pubs.usgs.gov/sir/2010/5052/)

Application Version: 4.3.8

NOAA Atlas 14, Volume 10, Version 3
Location name: Watertown, Connecticut, USA*
Latitude: 41.6436°, Longitude: -73.0809°
Elevation: 321.56 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.364 (0.277-0.478)	0.433 (0.329-0.569)	0.546 (0.413-0.720)	0.639 (0.481-0.847)	0.768 (0.562-1.06)	0.866 (0.622-1.22)	0.967 (0.675-1.40)	1.07 (0.719-1.60)	1.22 (0.790-1.88)	1.34 (0.846-2.10)
10-min	0.516 (0.392-0.677)	0.613 (0.466-0.807)	0.773 (0.585-1.02)	0.906 (0.682-1.20)	1.09 (0.796-1.50)	1.23 (0.881-1.73)	1.37 (0.956-1.99)	1.52 (1.02-2.27)	1.73 (1.12-2.67)	1.89 (1.20-2.98)
15-min	0.607 (0.461-0.797)	0.722 (0.548-0.949)	0.910 (0.689-1.20)	1.07 (0.803-1.41)	1.28 (0.936-1.77)	1.45 (1.04-2.03)	1.61 (1.13-2.34)	1.79 (1.20-2.67)	2.04 (1.32-3.14)	2.23 (1.41-3.50)
30-min	0.821 (0.624-1.08)	0.977 (0.742-1.29)	1.23 (0.932-1.63)	1.44 (1.09-1.91)	1.73 (1.27-2.39)	1.95 (1.40-2.75)	2.18 (1.52-3.16)	2.42 (1.62-3.61)	2.76 (1.78-4.25)	3.02 (1.91-4.74)
60-min	1.04 (0.787-1.36)	1.23 (0.935-1.62)	1.55 (1.18-2.05)	1.82 (1.37-2.41)	2.19 (1.60-3.01)	2.47 (1.77-3.46)	2.75 (1.92-3.99)	3.06 (2.04-4.55)	3.48 (2.25-5.36)	3.81 (2.41-5.98)
2-hr	1.36 (1.04-1.78)	1.61 (1.23-2.10)	2.00 (1.52-2.63)	2.33 (1.76-3.07)	2.78 (2.04-3.81)	3.13 (2.25-4.36)	3.48 (2.43-5.01)	3.85 (2.58-5.70)	4.34 (2.82-6.66)	4.73 (3.00-7.41)
3-hr	1.58 (1.21-2.06)	1.87 (1.43-2.43)	2.33 (1.77-3.04)	2.71 (2.05-3.56)	3.23 (2.38-4.42)	3.63 (2.62-5.06)	4.04 (2.84-5.81)	4.48 (3.01-6.62)	5.07 (3.30-7.76)	5.54 (3.52-8.64)
6-hr	2.00 (1.54-2.59)	2.38 (1.83-3.09)	3.01 (2.31-3.91)	3.53 (2.69-4.62)	4.25 (3.15-5.79)	4.79 (3.48-6.66)	5.35 (3.80-7.72)	5.99 (4.04-8.82)	6.89 (4.49-10.5)	7.64 (4.87-11.9)
12-hr	2.45 (1.89-3.15)	2.98 (2.31-3.84)	3.86 (2.97-4.99)	4.59 (3.52-5.96)	5.59 (4.17-7.62)	6.33 (4.65-8.83)	7.14 (5.13-10.4)	8.10 (5.48-11.9)	9.55 (6.24-14.5)	10.8 (6.91-16.7)
24-hr	2.85 (2.22-3.65)	3.56 (2.77-4.56)	4.72 (3.65-6.06)	5.68 (4.37-7.33)	7.00 (5.27-9.53)	7.97 (5.90-11.1)	9.04 (6.58-13.2)	10.4 (7.05-15.2)	12.5 (8.21-19.0)	14.4 (9.24-22.2)
2-day	3.21 (2.50-4.07)	4.07 (3.18-5.18)	5.48 (4.26-7.00)	6.66 (5.15-8.54)	8.27 (6.26-11.2)	9.44 (7.05-13.2)	10.8 (7.91-15.8)	12.5 (8.49-18.2)	15.3 (10.1-23.1)	17.8 (11.5-27.4)
3-day	3.48 (2.73-4.41)	4.43 (3.47-5.62)	5.99 (4.67-7.61)	7.28 (5.65-9.31)	9.05 (6.88-12.3)	10.3 (7.75-14.4)	11.8 (8.71-17.3)	13.7 (9.35-20.0)	16.9 (11.1-25.4)	19.7 (12.7-30.2)
4-day	3.73 (2.93-4.71)	4.75 (3.72-6.00)	6.40 (5.01-8.12)	7.78 (6.05-9.92)	9.67 (7.36-13.1)	11.0 (8.29-15.4)	12.6 (9.32-18.4)	14.6 (10.00-21.3)	18.0 (11.9-27.1)	21.1 (13.6-32.2)
7-day	4.44 (3.50-5.58)	5.58 (4.39-7.02)	7.44 (5.84-9.39)	8.98 (7.01-11.4)	11.1 (8.48-14.9)	12.7 (9.52-17.5)	14.4 (10.6-20.9)	16.6 (11.4-24.1)	20.3 (13.4-30.4)	23.6 (15.3-36.0)
10-day	5.16 (4.08-6.47)	6.36 (5.02-7.98)	8.32 (6.55-10.5)	9.95 (7.78-12.6)	12.2 (9.31-16.3)	13.8 (10.4-19.0)	15.6 (11.5-22.5)	18.0 (12.3-25.9)	21.7 (14.4-32.4)	25.0 (16.2-38.0)
20-day	7.43 (5.90-9.25)	8.68 (6.89-10.8)	10.7 (8.48-13.4)	12.4 (9.76-15.6)	14.7 (11.3-19.5)	16.5 (12.4-22.3)	18.3 (13.5-25.9)	20.6 (14.2-29.5)	24.1 (16.0-35.8)	27.1 (17.6-41.1)
30-day	9.32 (7.43-11.6)	10.6 (8.42-13.1)	12.6 (10.0-15.8)	14.4 (11.3-18.0)	16.7 (12.8-21.9)	18.5 (13.9-24.8)	20.3 (14.9-28.4)	22.5 (15.6-32.1)	25.7 (17.1-38.0)	28.3 (18.5-42.8)
45-day	11.6 (9.30-14.4)	12.9 (10.3-16.0)	15.0 (12.0-18.7)	16.8 (13.3-21.0)	19.2 (14.7-24.9)	21.0 (15.8-27.9)	22.9 (16.7-31.5)	24.9 (17.3-35.4)	27.7 (18.5-40.8)	29.8 (19.5-45.0)
60-day	13.5 (10.8-16.7)	14.9 (11.9-18.4)	17.1 (13.6-21.1)	18.9 (15.0-23.5)	21.4 (16.4-27.6)	23.3 (17.5-30.7)	25.2 (18.2-34.3)	27.0 (18.8-38.3)	29.4 (19.7-43.3)	31.2 (20.4-46.9)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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PF graphical

APPENDIX B – CROSS-SECTION LOCATIONS AND CROSS-SECTIONS

ARCHITECTURE
ENGINEERING
ENVIRONMENTAL
LAND SURVEYING

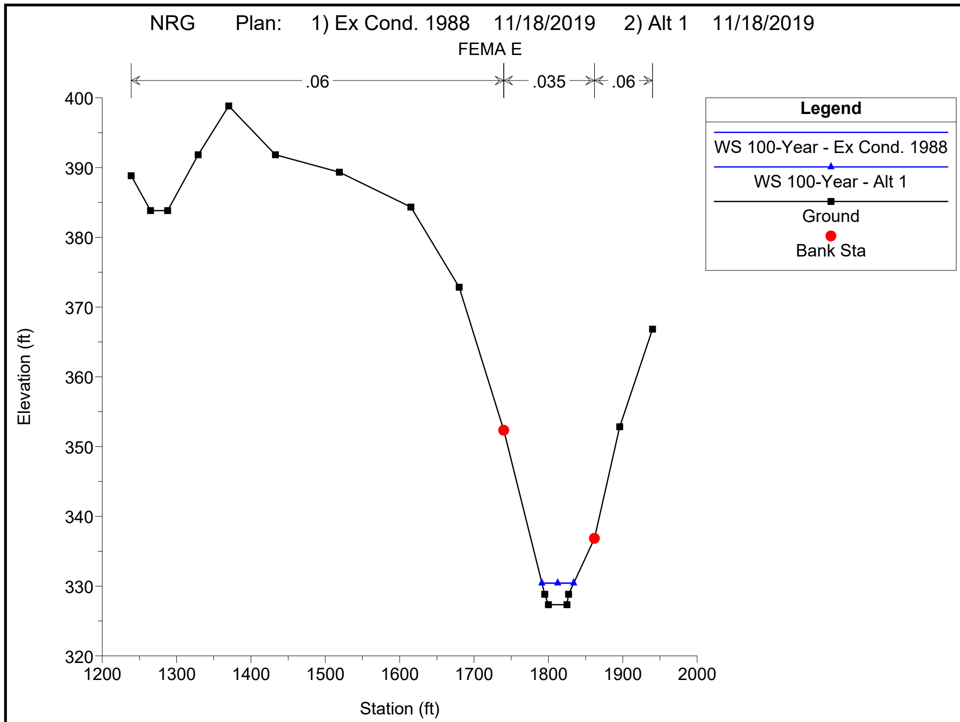
CROSS-SECTION LOCATION

NAUGATUCK RIVER GREENWAY
PEDESTRIAN BRIDGE OVER
BRANCH BROOK

Designed	B.G.R.
Drawn	B.G.R.
Reviewed	D.M.C.
Scale	1"= 400'
Project No.	1800579
Date	11/13/19
CAD File	CROSS_SECTIONS

LOC

Xref (s): ; 42224.00 Thomaston ; PR-422400 ; 8X11(port)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FEMA E
.06
.035
.06
Legend
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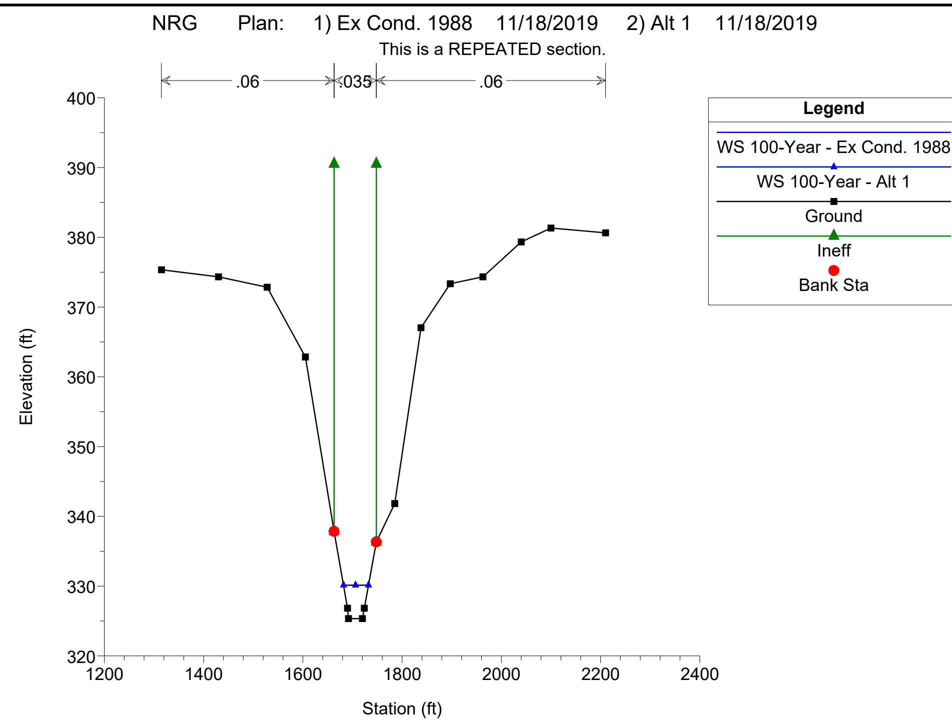
WS 100-Year - Alt 1
Ground
Bank Sta
Elevation (ft)
Station (ft)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.06
.035
.06
Legend
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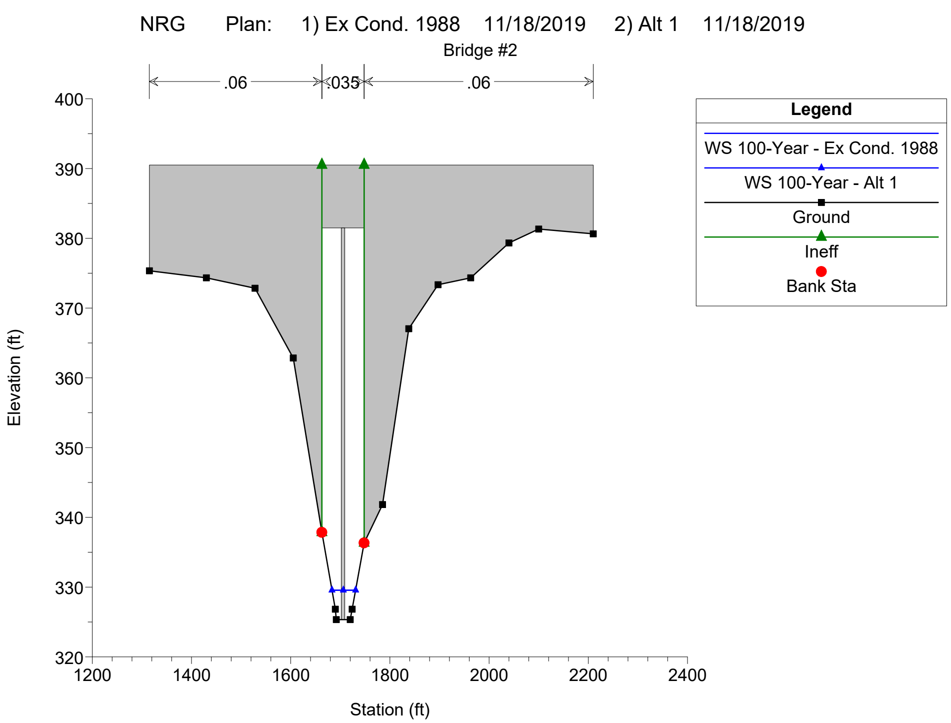
WS 100-Year - Alt 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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Bridge #2
.06
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.06
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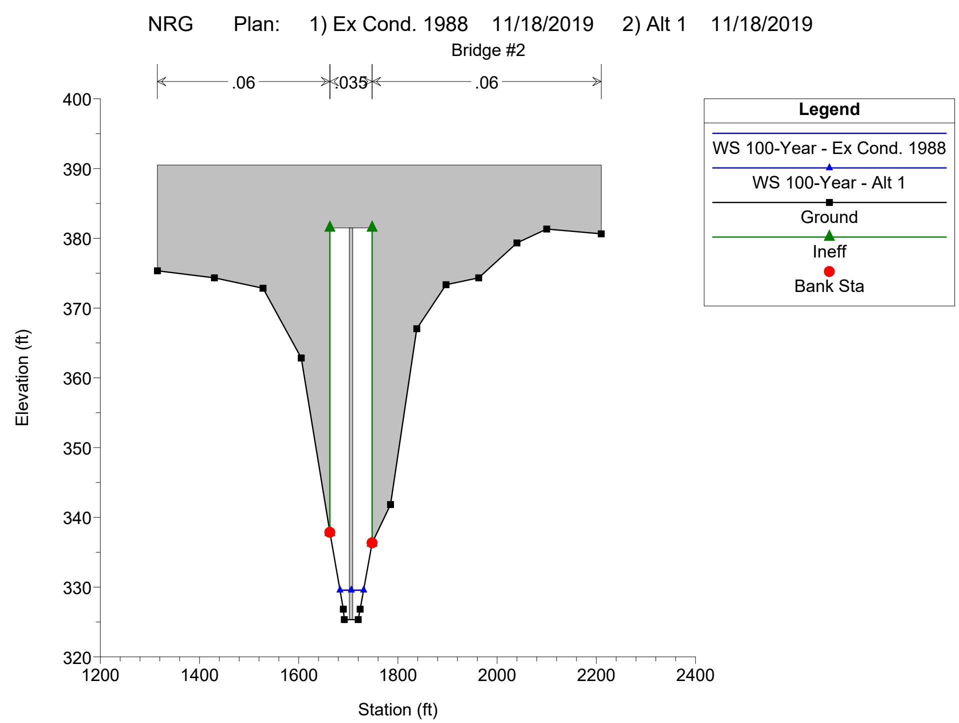
WS 100-Year - Alt 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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Bridge #2
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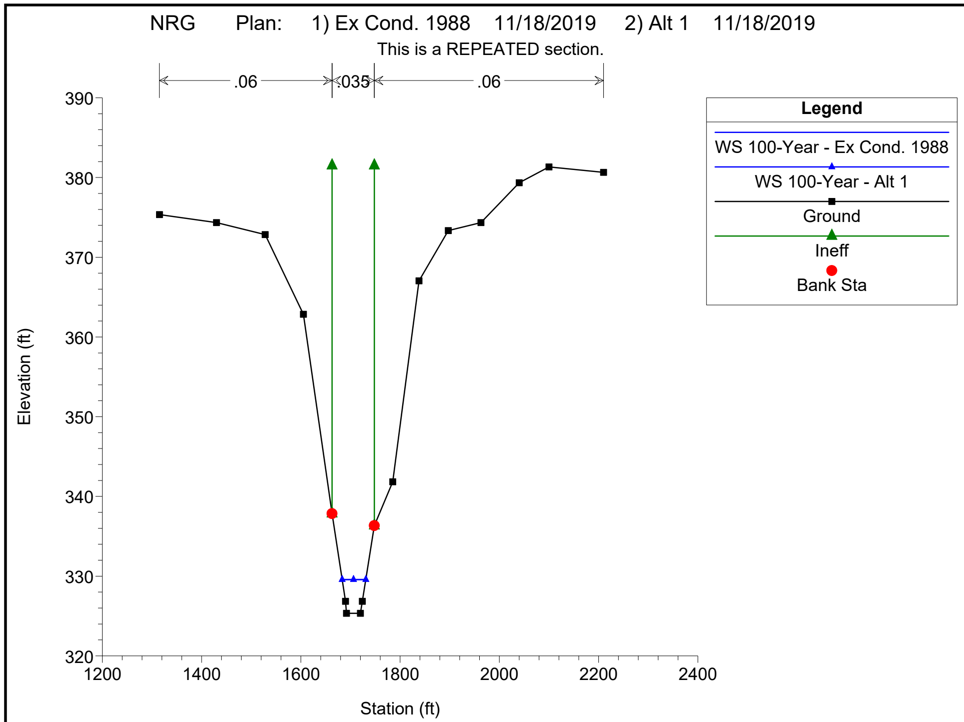
WS 100-Year - Alt 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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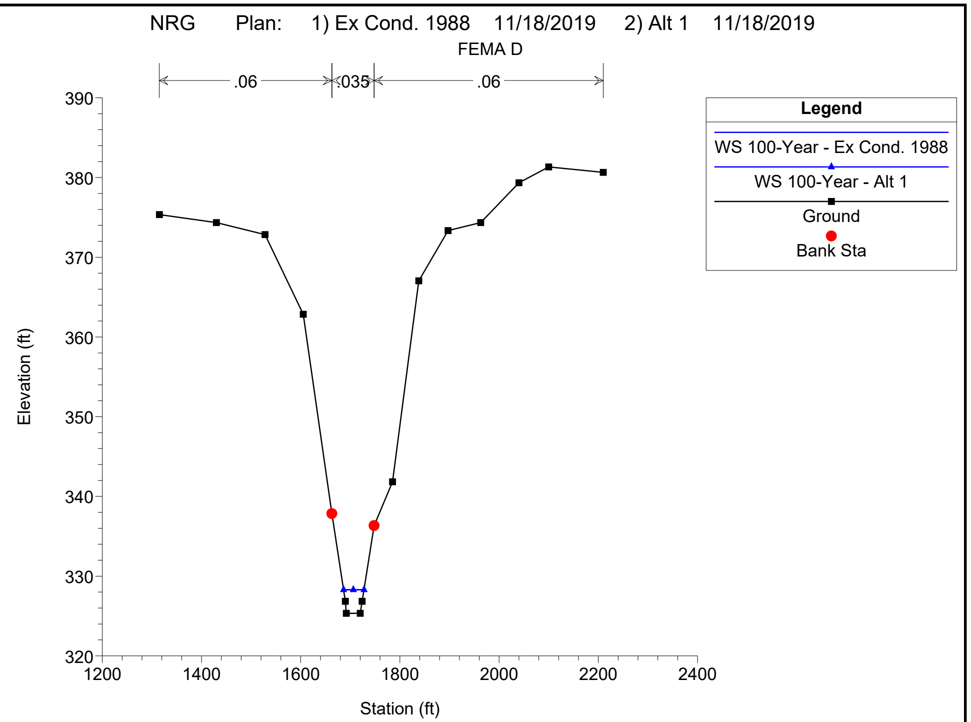
WS 100-Year - Alt 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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FEMA D
.06
.035
.06
Legend
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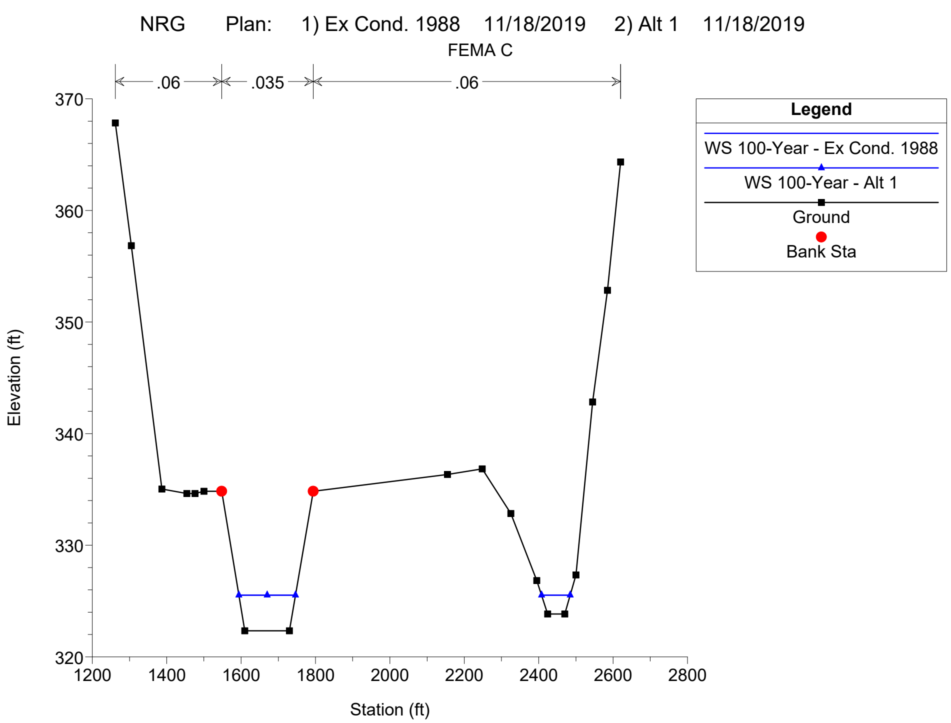
WS 100-Year - Alt 1
Ground
Bank Sta
Elevation (ft)
Station (ft)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Legend
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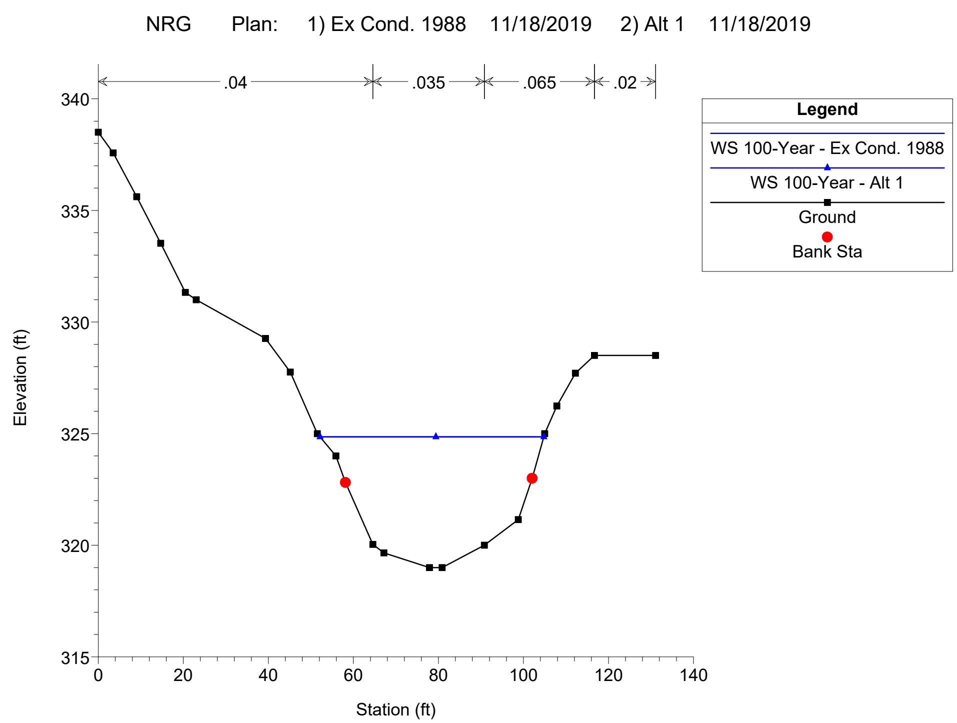
WS 100-Year - Alt 1
Ground
Bank Sta
Elevation (ft)
Station (ft)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.04
.035
.065
.02
Legend
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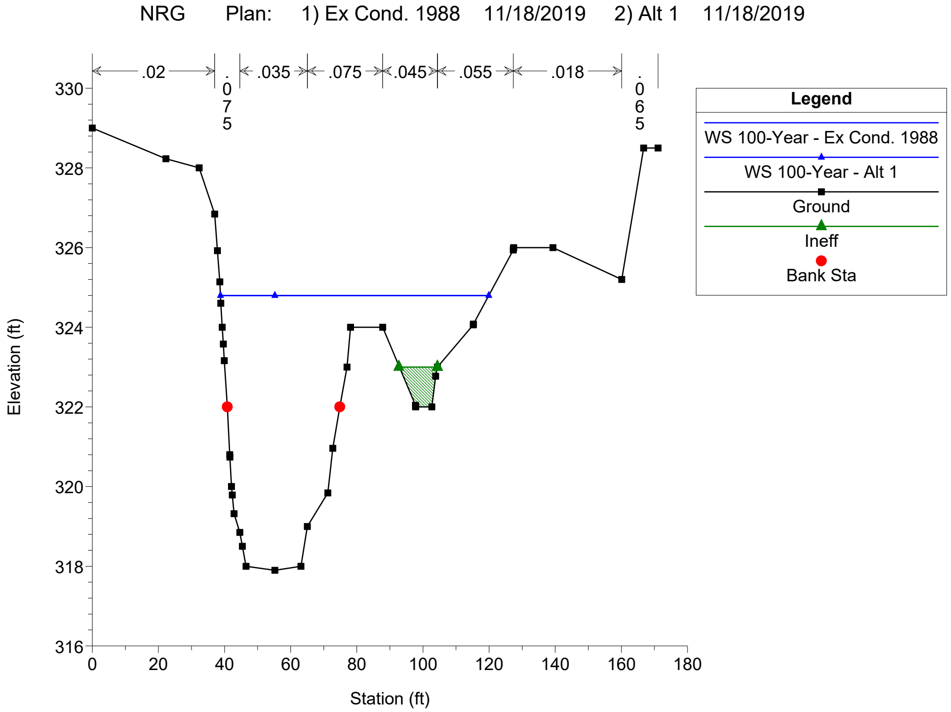
WS 100-Year - Alt 1
Ground
Bank Sta
Elevation (ft)
Station (ft)



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.02
.075
.035
.075
.045
.055
.018
.065
Legend
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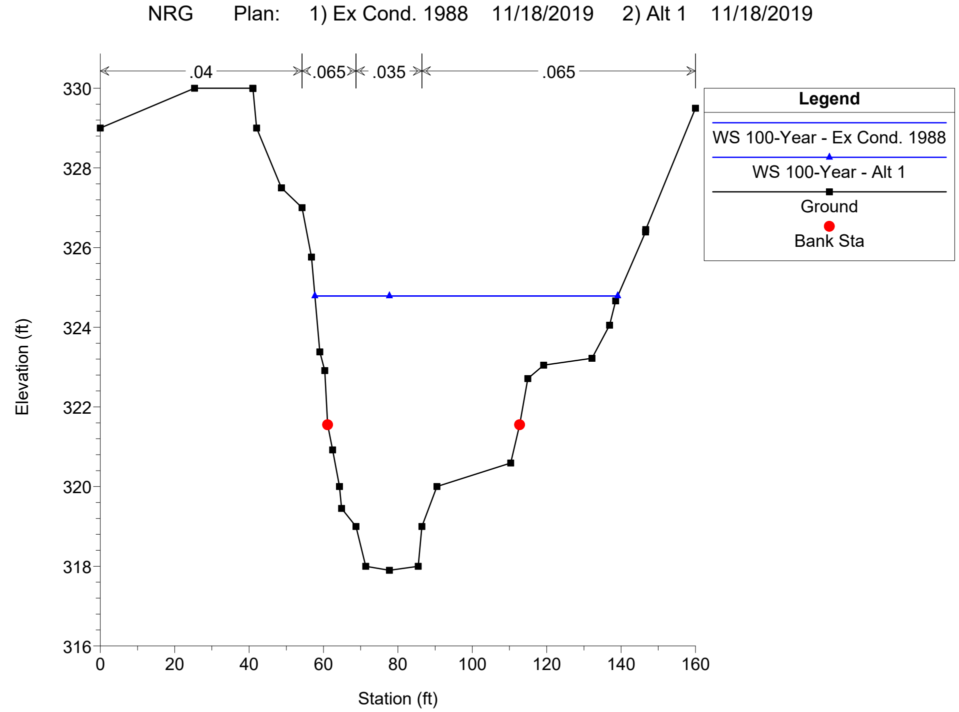
WS 100-Year - Alt 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)



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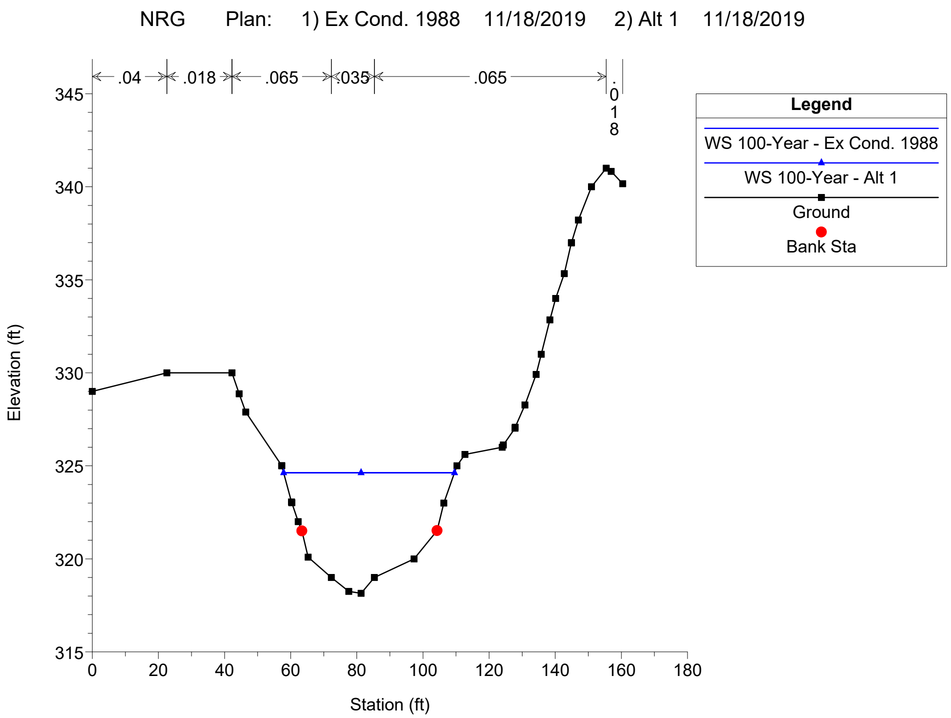
WS 100-Year - Alt 1
Ground
Bank Sta
Elevation (ft)
Station (ft)



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Legend
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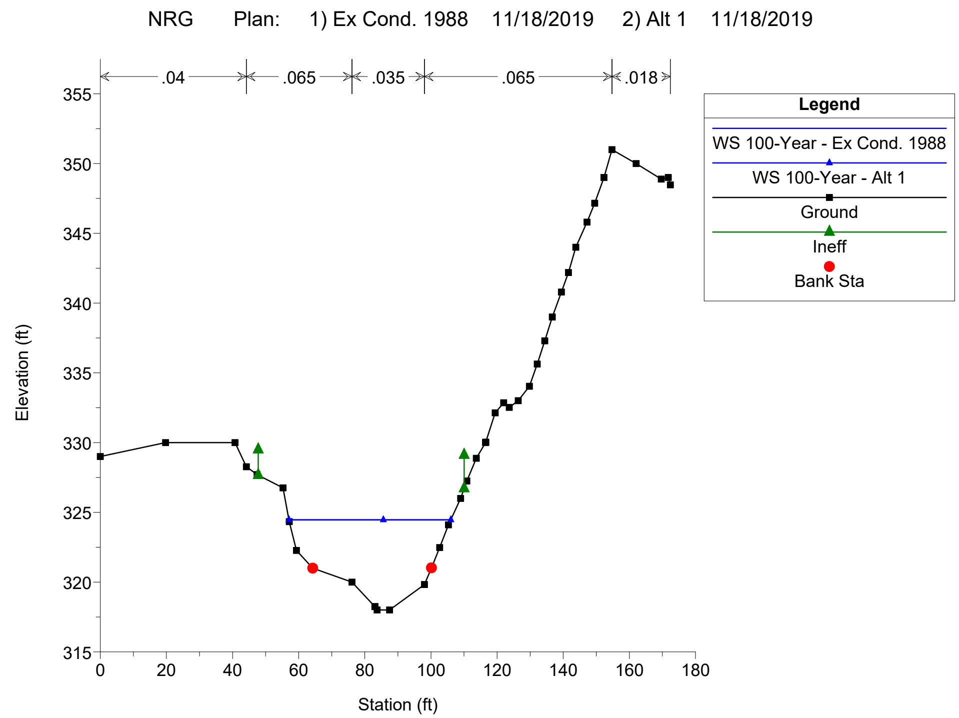
WS 100-Year - Alt 1
Ground
Bank Sta
Elevation (ft)
Station (ft)



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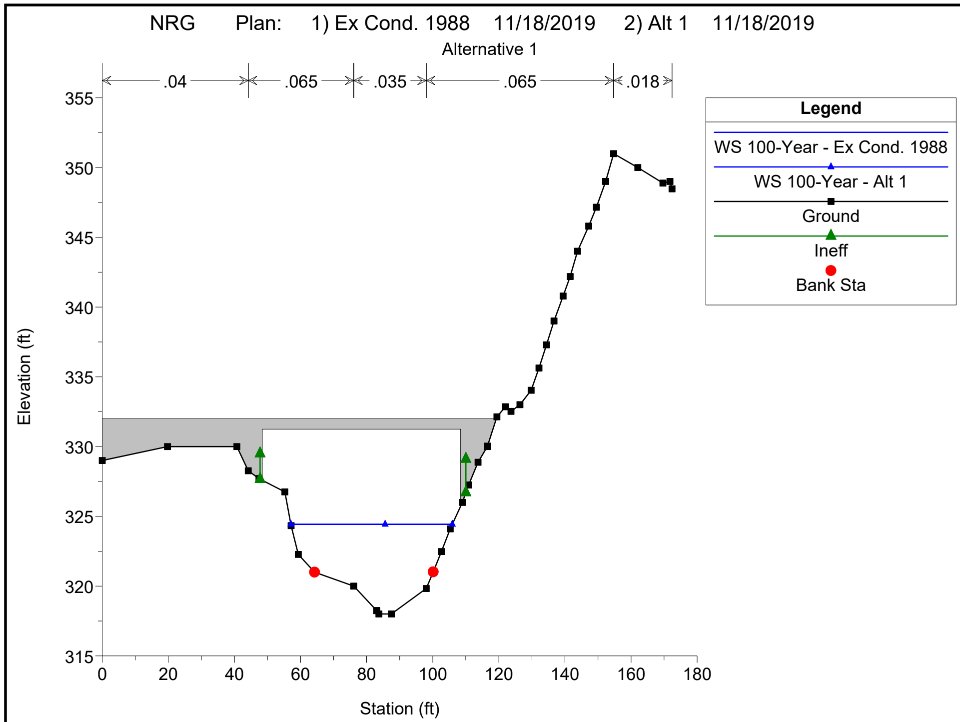
Legend
WS 100-Year - Ex Cond. 1988
WS 100-Year - Alt 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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Alternative 1
.04 .065 .035 .065 .018
Legend
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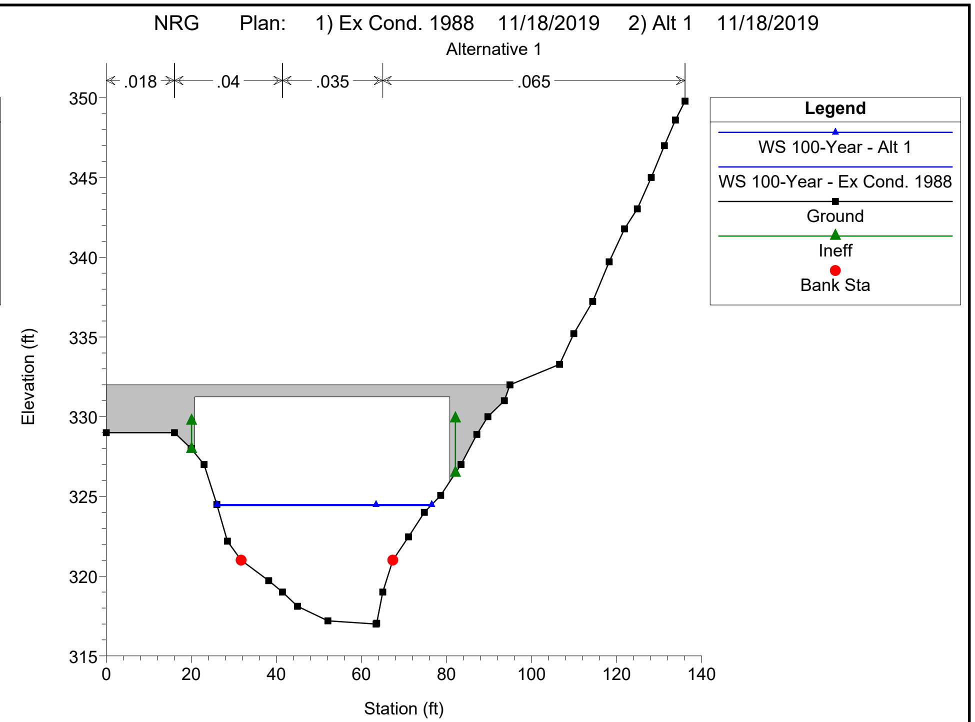
WS 100-Year - Alt 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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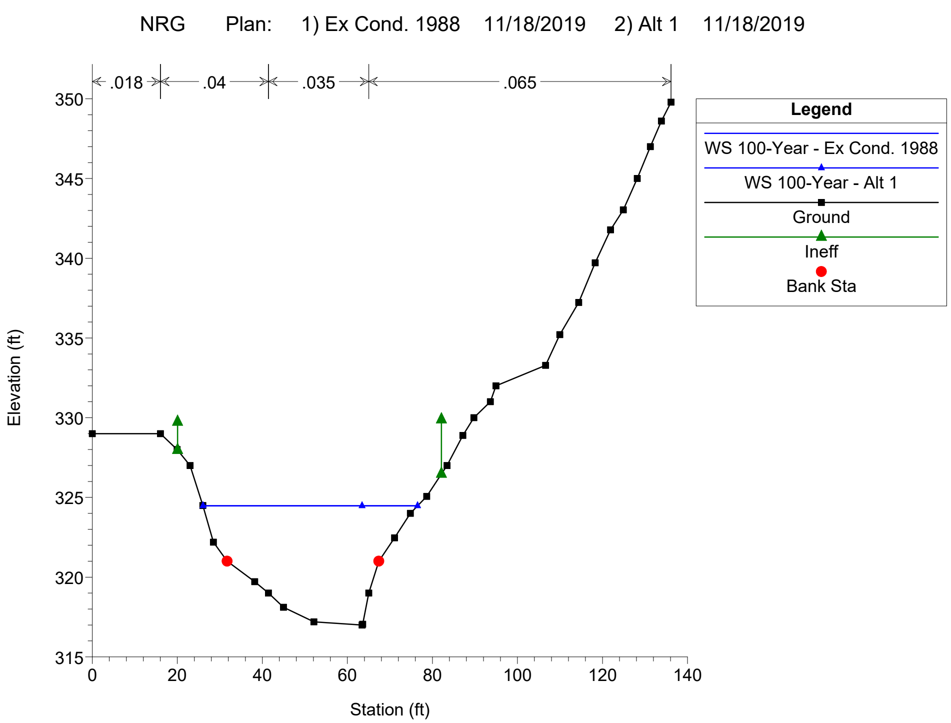
Alternative 1
.018 .04 .035 .065
Legend
WS 100-Year - Alt 1
WS 100-Year - Ex Cond. 1988
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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Legend
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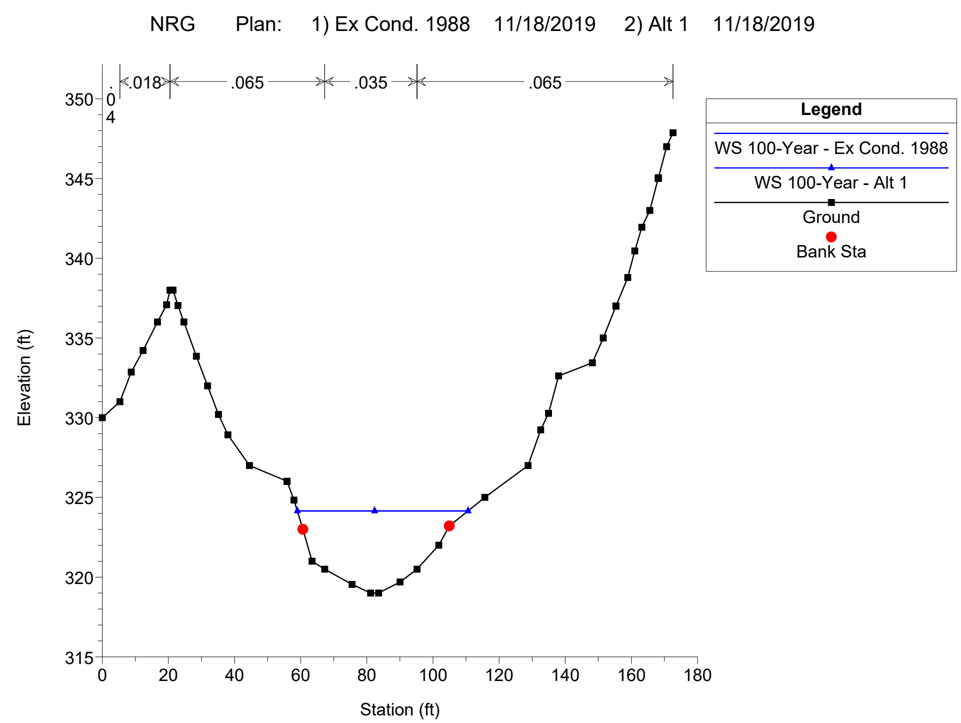
WS 100-Year - Alt 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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Legend
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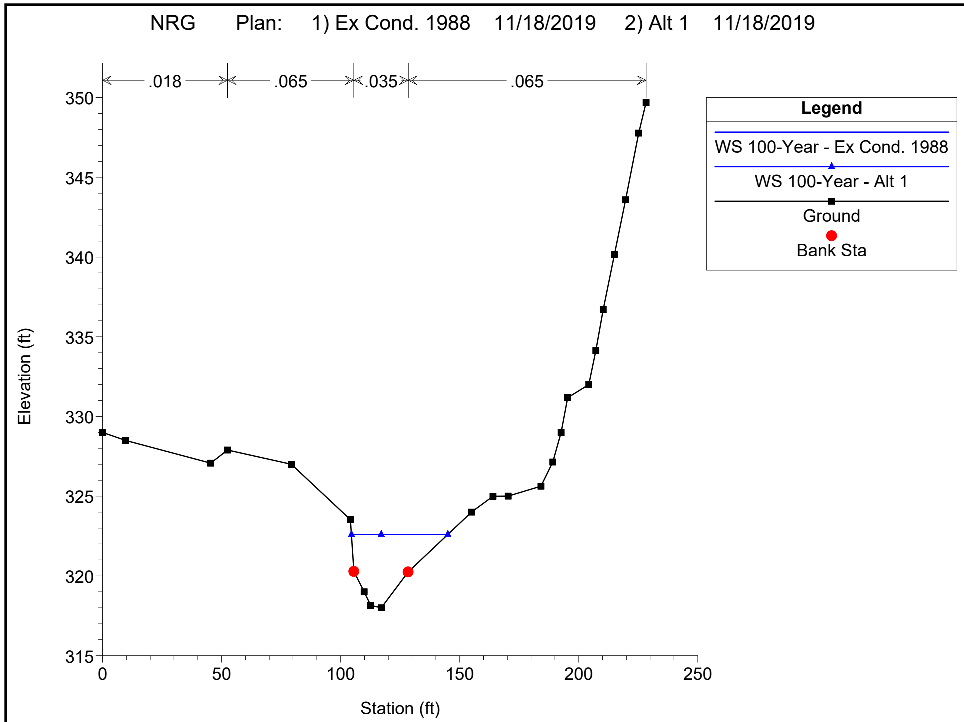
WS 100-Year - Alt 1
Ground
Bank Sta
Elevation (ft)
Station (ft)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.018
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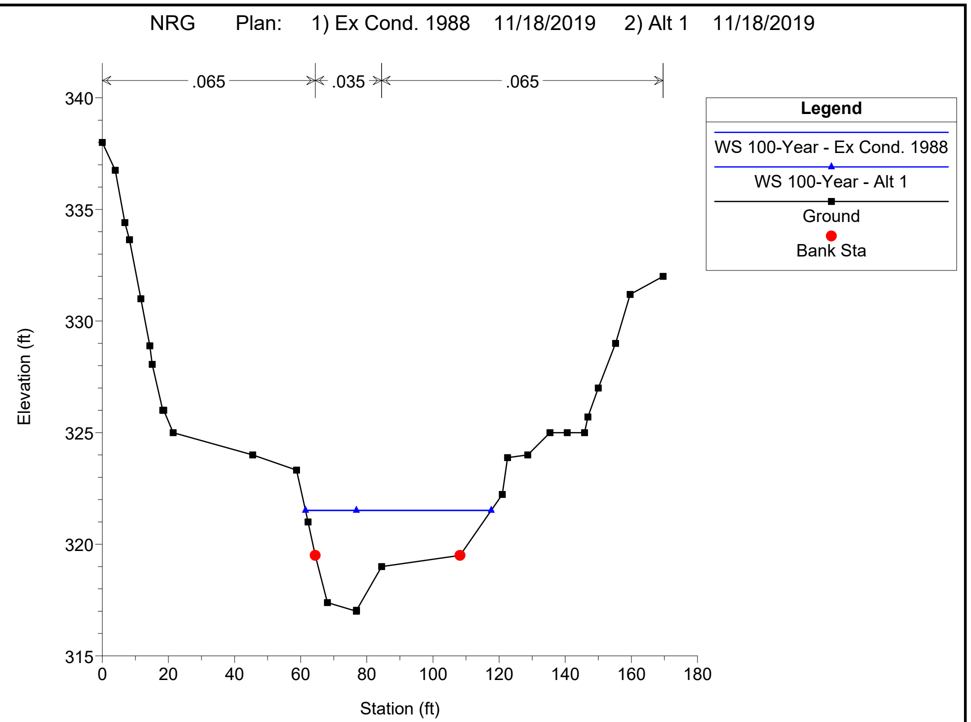
Legend
WS 100-Year - Ex Cond. 1988
WS 100-Year - Alt 1
Ground
Bank Sta
Elevation (ft)
Station (ft)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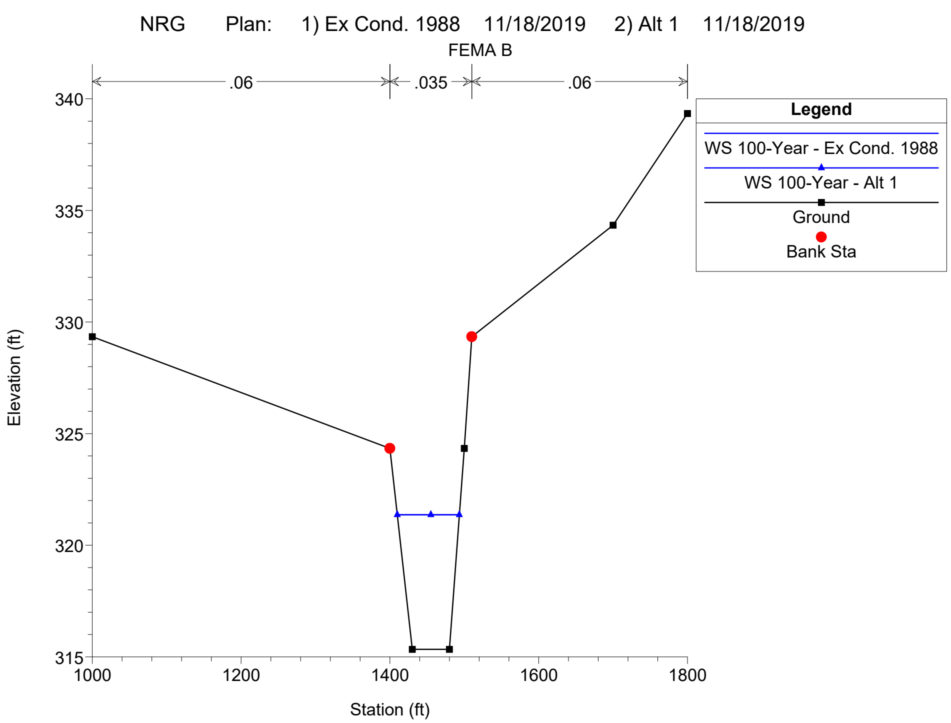
WS 100-Year - Alt 1
Ground
Bank Sta
Elevation (ft)
Station (ft)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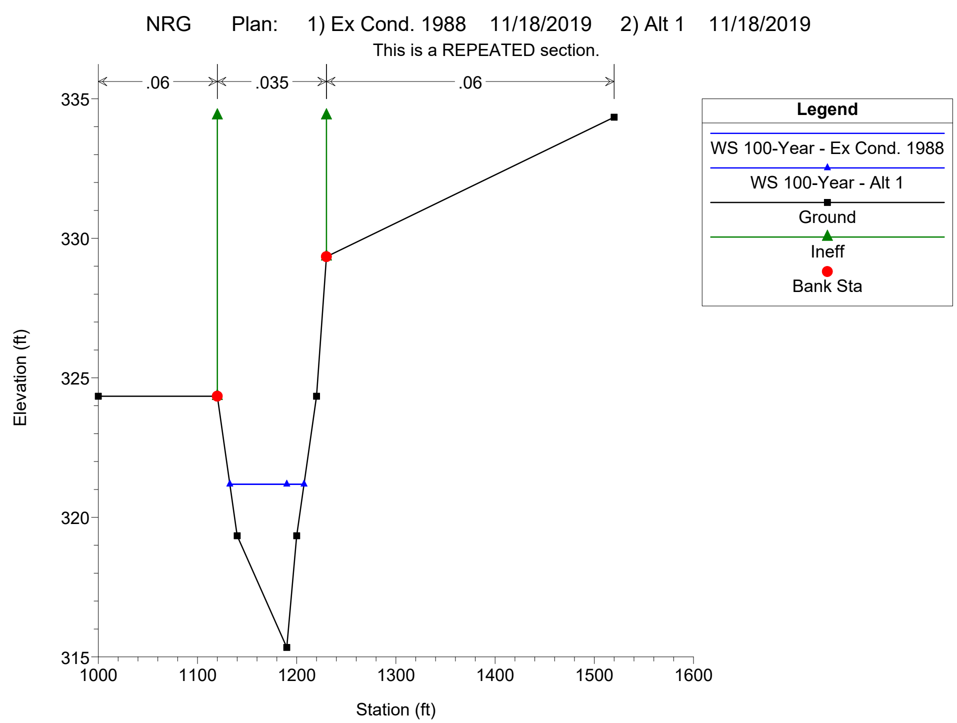
WS 100-Year - Alt 1
Ground
Bank Sta
Elevation (ft)
Station (ft)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.06
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Legend
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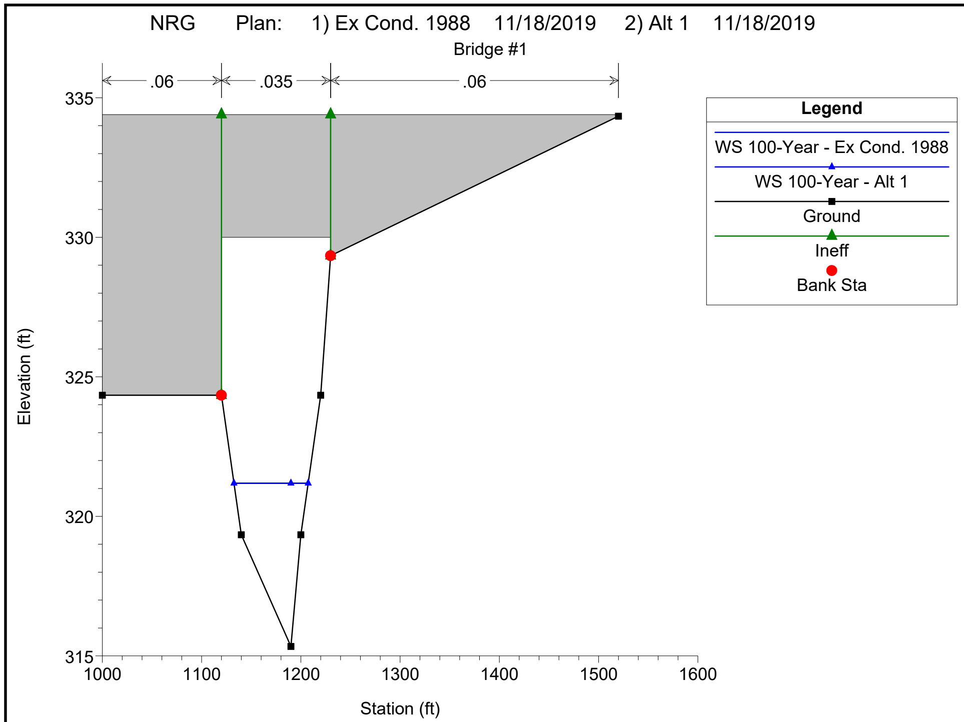
WS 100-Year - Alt 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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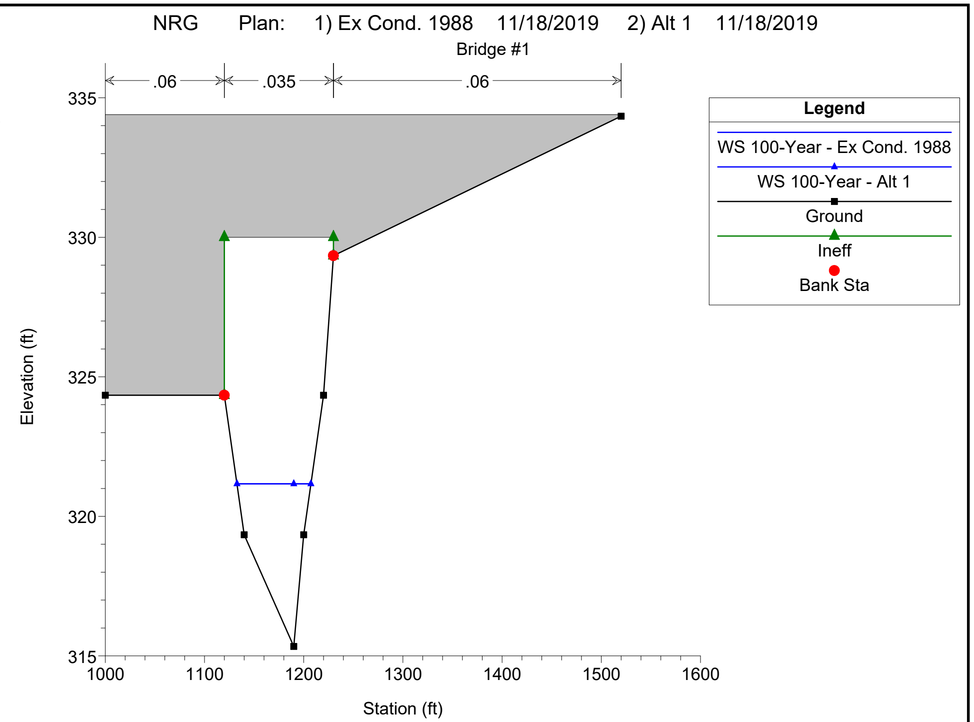
Bridge #1
.06
.035
.06
Legend
WS 100-Year - Ex Cond. 1988
WS 100-Year - Alt 1
Ground
Ineff
Bank Sta
Elevation (ft)
315
320
325
330
335
Station (ft)
1000
1100
1200
1300
1400
1500
1600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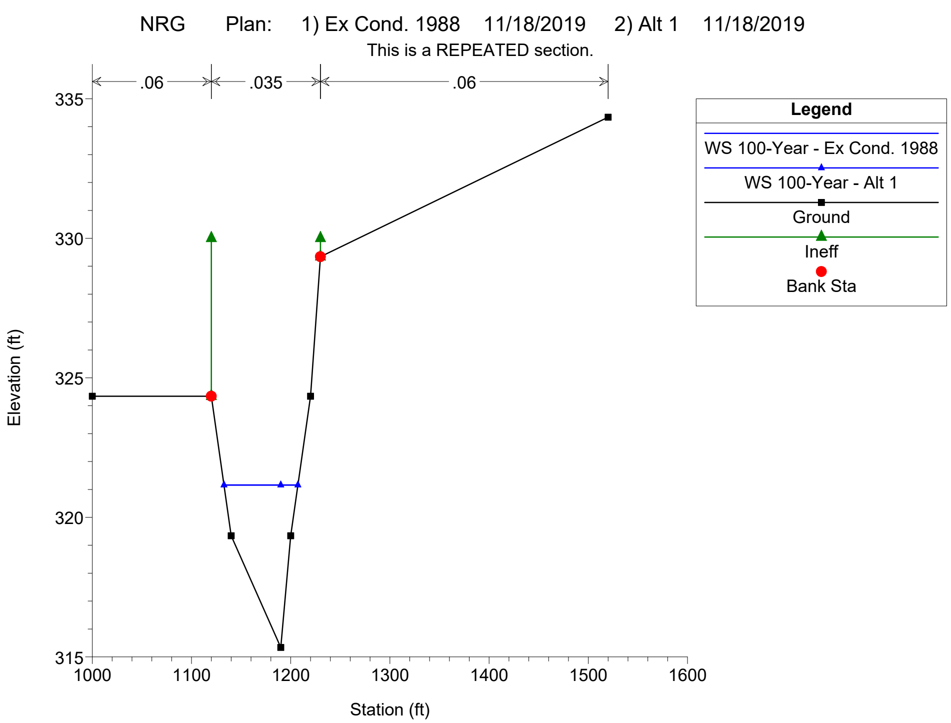
Bridge #1
.06
.035
.06
Legend
WS 100-Year - Ex Cond. 1988
WS 100-Year - Alt 1
Ground
Ineff
Bank Sta
Elevation (ft)
315
320
325
330
335
Station (ft)
1000
1100
1200
1300
1400
1500
1600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This is a REPEATED section.
.06
.035
.06
Legend
WS 100-Year - Ex Cond. 1988
WS 100-Year - Alt 1
Ground
Ineff
Bank Sta
Elevation (ft)
315
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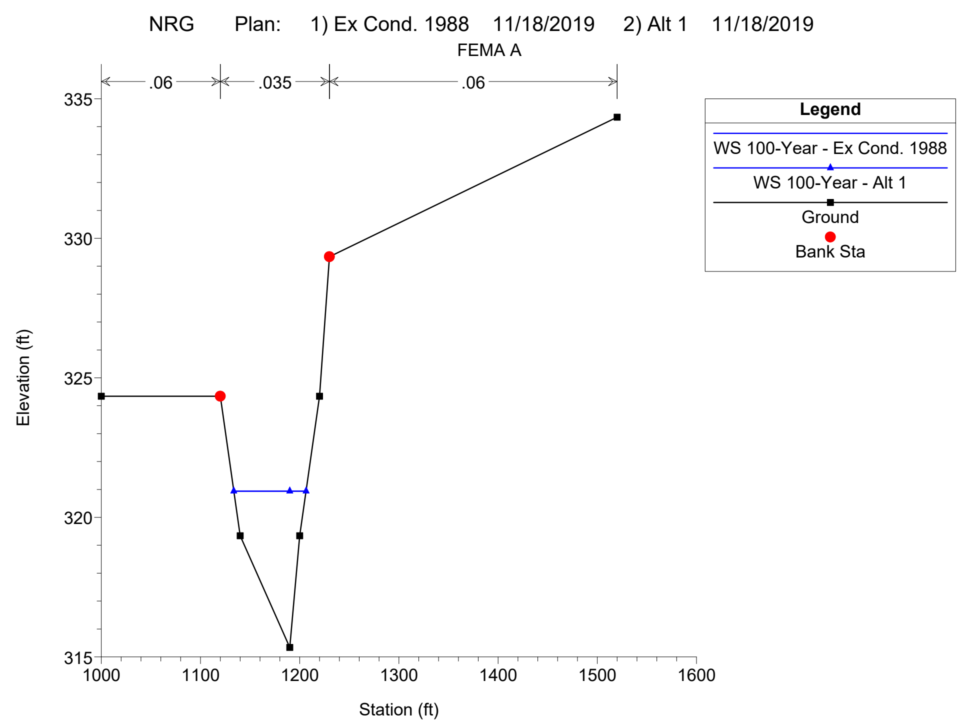
1200
1300
1400
1500
1600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FEMA A
.06
.035
.06
Legend
WS 100-Year - Ex Cond. 1988
WS 100-Year - Alt 1
Ground
Bank Sta
Elevation (ft)
315
320
325
330
335
Station (ft)
1000
1100
1200
1300
1400
1500
1600

APPENDIX C – DATA COLLECTION AND FIELD REVIEW & LEVEL I SCOUR ANALYSIS

HYDRAULIC DATA FORMS

- **Data Collection and Field Review (pages 4 to 14)**
- **Hydraulic Data (pages 15 to 18)**

A. DATA COLLECTION AND FIELD REVIEW

I. GENERAL PROJECT DATA

Bridge No.: **N/A**
Town: **Watertown & Thomaston** County: **Litchfield**
Feature carried: **Multipurpose Path** Feature crossed: **Branch Brook**
Quadrangle: **Thomaston** DEP watershed basin no.: **6910**

Functional class:

- ☐ urban principal arterial-interstate
- ☐ urban principal arterial-other expwy.
- ☐ urban principal arterial-other
- ☐ urban minor arterial
- ☐ urban collector
- ☐ urban local
- ☐ rural principal arterial-interstate
- ☐ rural principal arterial-other expwy.
- ☐ rural principal arterial-other
- ☐ rural minor arterial
- ☐ rural major collector
- ☐ rural minor collector
- ☒ Other

Year built: **New Construction** Year of reconstruction: ______
Overall NBIS structure rating: ______ NBIS Item 113: ______
USGS total scour index: ______ Sufficiency rating: ______

Plans available? ☐ yes ☒ no

II. SUPERSTRUCTURE INFORMATION

Bridge width: **N/A** ft Bridge length: **N/A** ft
Number of spans: **N/A** Bridge skew: **N/A**

Bearing connection type: ☒ Positive connection ☐ No positive connection

III. HYDROLOGIC AND HYDRAULIC INFORMATION

Watershed area: **22.6** sq. mi.

Is it tidally influenced? ☐ yes ☒ no

What information is available?

- ☐ hydraulic report
- ☐ scour report
- ☐ floodway analysis report
- ☐ SCEL analysis
- ☐ comparative report
- ☒ FEMA F.I.S.
- ☒ Other: **FEMA HEC-2 Backup Data**

	Source	2 Yr. Event	10 Yr. Event	50 Yr. Event	100 Yr. Event	500 Yr. Event
Flow rates (cfs)	**FEMA Flows**	**-**	**800**	**800**	**900**	**2,300**
	PeakFq for Gage No. 01208013	**560**	**770**	**940**	**1,010**	**1,180**
Precipitation (in)	**NOAA Atlas 14 24-hr**	**3.56**	**5.68**	**7.97**	**9.04**	**12.5**

Elevations (ft.)								
At Structure			Water Surface at Approach Cross-Section (200.65)					
Streambed	Low Chord	Roadway	2 Yr. Event	10 Yr. Event	50 Yr. Event	100 Yr. Event	500 Yr. Event	
318.00	**NA**	**NA**	**-**	**324.31**	**324.31**	**324.63**	**327.90**	

Pressure flow at design storm? ☐ yes ☐ underclearance ft.

Comments: **This is a new structure that does not currently exist. The streambed above is at Section 200.6, the location of the upstream face section of the proposed bridge. The WSELs listed above are from the Existing Conditions Model at Section 200.65, the approach section.**

IV. SITE DATA

A. Existing structure(s) – Provide sketch of culvert/structure with dimensions and brief description.

No Existing Structure
See Figures
See Appendix A (Photographs)

Comments: Include structure or culvert type and condition. Note particularly any scour adjacent to abutments or at culvert outlet and the presence of debris or sediment. Also note the location of any utilities in the area of the crossing.

B. High water marks – Describe the nature and location of any apparent high-water marks and relate to a date of occurrence, if possible.

N/A

C. Maximum allowable headwater – Describe the nature of the apparent controlling feature and note its location.

N/A

D. Fish passage requirements – Comment on the apparent need for fish passage or impediments to same; such as dams or restrictive crossings in the area.

The proposed bridge allows fish passage. Fish passage is blocked approximately 0.5 miles upstream of the subject location by the Black Rock Dam spillway.

V. PERIPHERAL SITE DATA

A. Hydraulic control – Note location and description.

The flood control structure upstream and known FEMA WSELs downstream of the project site at the mouth of Naugatuck River control.

B. Upstream and downstream structures – Provide sketches and brief descriptions of existing bridges/culverts. Include dimensions.

Upstream

- **Route 8 Overpass – twin span, 8-ft wide pier, 381.50 ft low chord, 85 ft span abutment to abutment.**

Downstream

- **Dirt road crossing – 330.00 ft low chord, 100 ft wide opening**

C. Watershed area – Check watershed boundaries for accuracy. Note current land uses within watershed.

See Appendix A

D. Flow control structures within watershed – Note the location and type of all significant flow control structures (dams, etc.) within the watershed. Provide sketches with dimensions as required.

Spillway 2,100-ft upstream.
See Appendix A.

E. Site photographs – Attach to report. Include an index and sketch of photograph locations. **No current photographs.**

VI. STREAM CHANNEL AND RELATED ASPECTS

A. Stream characterization

Twenty Groupings of Stream Characteristics (check box)

	Identifier	Drainage Area	Streambed Slope	Streambed Soils	Land Use
☐	A	Large	Low	SD	S/F
☐	B	Large	Low	SD	Urban
☒	C	Large	Moderate	SD	Forested
☐	D	Medium	Moderate	SD	Urban
☐	E	Medium	Moderate	SD	S/F
☐	F	Medium	Moderate	CLAY	S/F
☐	G	Medium	Moderate	TILL	S/F
☐	H	Medium	Moderate	SD	Forested
☐	I	Medium	Moderate	TILL	Forested
☐	J	Small	Low	SD	Urban
☐	K	Small	Moderate	TILL	Urban
☐	L	Small	Low	SD	S/F
☐	M	Small	Moderate	SD	S/F
☐	N	Small	Moderate	SD	Forested
☐	O	Small	Low	CLAY	S/F
☐	P	Small	Steep	TILL	S/F
☐	Q	Small	Moderate	TILL	S/F
☐	R	Small	Low	TILL	S/F
☐	S	Small	Moderate	TILL	Forested
☐	T	Small	Steep	TILL	Forested

Drainage area	Small	$\leq$ 64.75km^2 (25 mi^2)
	Medium	> 64.75km^2 (25 mi^2) and $\leq$ 259 km^2 (100 mi^2)
	Large	> 259 km^2 (100 mi^2)
Streambed slope	Low	$\leq$ 4.76 m/km (25 ft/mi)
	Moderate	> 4.76 m/km (25 ft/mi) and $\leq$ 19.05 m/km (100 ft. mi)
	Steep	> 19.05 m/km (100 ft. mi)
Streambed soils	SD = Stratified Drift	
Land Use	S/F = Suburban or Farming	

B. Channel stability

Previous NBIS Item 61 rating: **NA**

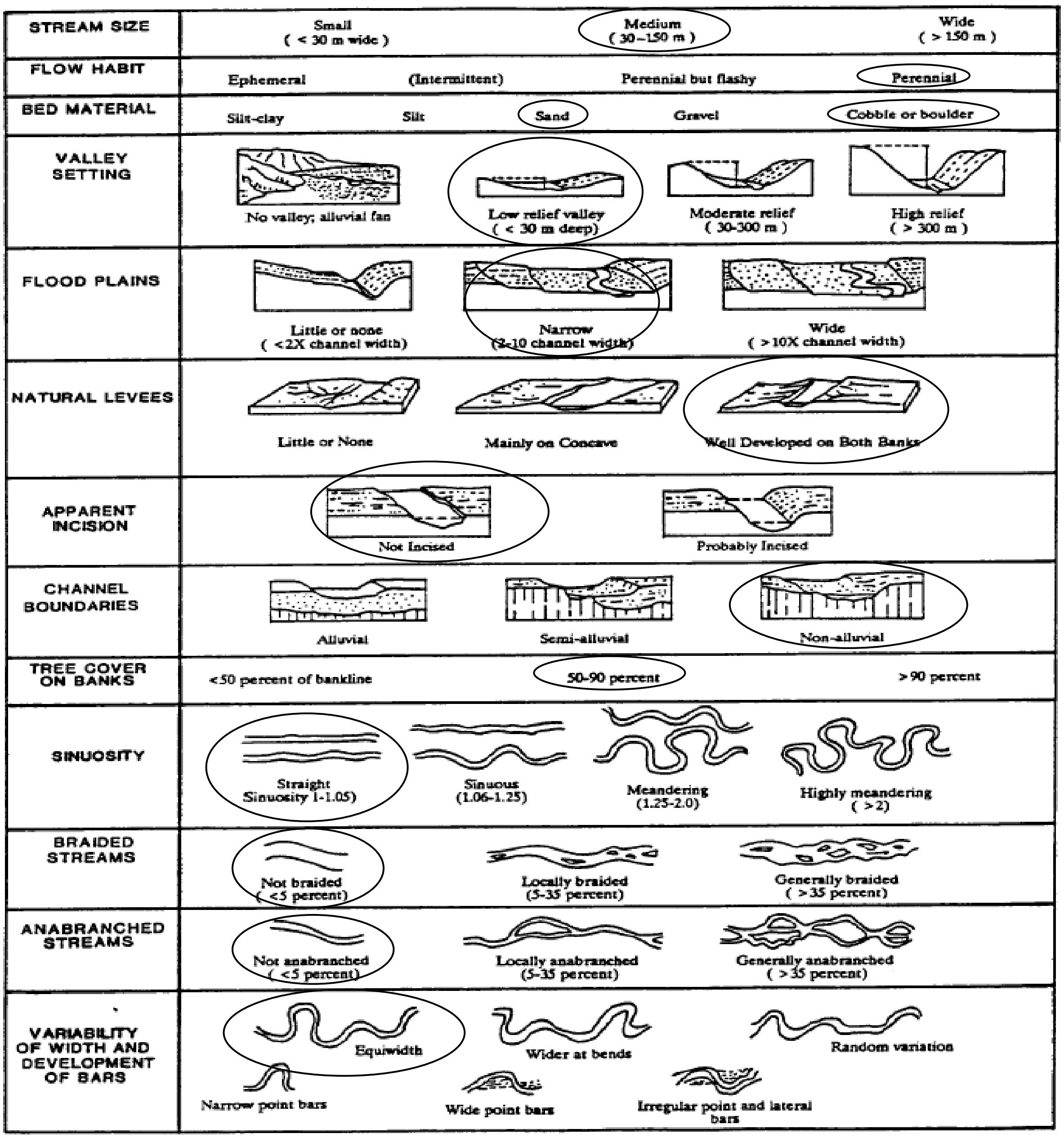
Lateral stability: ☒ stable ☐ unstable

Bank erosion:
☒ none ☐ light fluvial erosion ☐ heavy fluvial erosion ☐ mass wasting

Streambed: ☒ stable ☐ aggradating ☐ degrading

Armoring potential: ☐ none ☒ low ☐ moderate ☐ high

Geomorphic factors that affect stream stability (circle factors that apply)



Source: Adapted From Brice and Blodgett, 1978

(See also FHWA HEC-20, "Stream Stability at Highway Structures" for discussion of the above factors)

Secondary bed material: ☐ sand ☐ gravel ☐ boulders ☐ manmade
☐ silt/clay ☐ cobble ☐ bedrock

Bank protection

Type ☒ none ☐ modified ☐ intermediate ☐ standard
☐ concrete ☐ slope paving ☐ absent
☐ other

Condition ☒ n/a ☐ good ☐ weathered ☐ slumped
☐ poor ☐ missing ☐ fair

Comment on the need (if any) for training walls, cutoff walls or special slope or channel protection.

The side slopes of the brook in the vicinity of the bridge are generally stable. Backwater from the crossing downstream reduces velocities in project location.

C. Channel and overbank roughness coefficients

Basic channel description: ☐ channel in earth ☐ channel cut into rock
☐ channel fine gravel ☒ channel coarse gravel

Surface irregularity of channel:
☐ smooth – best obtainable section for materials involved
☒ minor – slightly eroded or scoured side slopes
☐ moderate – moderately sloughed or eroded side slopes
☐ severe – badly sloughed banks of natural channels or badly eroded sides of man-made channels – jagged and irregular sides or bottom sections of channels in rock

Variations in shape and size of cross sections
☐ changes in size or shape occurring gradually
☒ large and small sections alternating occasionally or shape changes causing occasional shifting of main flow from side to side
☐ moderate – moderately sloughed or eroded side slopes
☐ large and small sections alternating frequently or shape changes causing frequent shifting of main flow from side to side

Channel obstructions – (Judge the relative effect of obstructions – consider the degree to which the obstructions reduce the average cross sectional area, character of obstructions, and location and spacing of obstructions).

NOTE: Smooth or rounded objects create less turbulence than sharp, angular objects.

The effect of obstructions is:

☐ negligible
☒ minor
☐ appreciable
☐ severe

Degree of Vegetation (Note amount and character of foliage)

The effect of vegetative growth upon flow conditions is:

☐ LOW – Dense growths of flexible turf grasses where average depth of flow is 2 to 3 times the height of vegetation. Supple seedling tree switches where the average depth of flow is 3 to 4 times the height of the vegetation.

☐ MEDIUM – Turf grasses where the average depth of flow is 1 to 2 times the height of vegetation. Stemmy grasses, weeds or tree seedlings (moderate cover) where the average depth of flow is 2 to 3 times the height of vegetation. Bushy growths (moderately dense along channel side slopes with no significant vegetation along channel bottom).

☒ HIGH – Turf grasses where average height is about equal to the average depth of flow. Willow or cottonwood trees 8 to 10 years old with some weeds or brush. Bushy growths about 1 year old with some weeds. No significant vegetation along channel bottom.

☐ VERY HIGH – Turf grasses where the average depth of flow is less than ½ the height of vegetation. Bushy growths about 1-year old intergrown with weeds. Dense growth of cattails along channel bottom. Trees intergrown with weeds and brush (thick growth).

Additional Comments: **See Appendix A**

VII. HYDRAULIC VULNERABILITY

Previous Item 71 rating: **NA**

Is there confluence present? ☐ yes ☒ no

Angle of attack (flood flow): ☐ yes ☒ no

Bends in channel: ☒ upstream of bridge ☒ downstream of bridge ☐ straight channel reach ☐ at bridge

Velocity order of magnitude: **4.14 ft/s (approach section)**

Trapping potential: ☒ low ☐ medium ☐ high

Debris potential: ☒ low ☐ medium ☐ high

Overtopping relief: ☒ none ☐ left approach ☐ right approach ☐ on bridge ☐ relief bridge ☐ cannot be determined

Primary bed material: ☒ sand ☒ gravel ☐ boulders ☐ manmade ☐ silt/clay ☐ cobble ☐ bedrock

Comments: **The channel is comprised of gravelly sand, small cobbles and boulders.**

VIII. VISUAL SCOUR EVIDENCE

USGS observed scour index: **N/A**

History of scour problem: ☐ yes ☒ no

Comments: **There is no existing bridge at the crossing site.**

Note: Comment should address any evidence of scour at ALL substructure units.

CONTRACTION SCOUR SUSCEPTIBILITY

Channel width upstream: **40-ft**
Channel width under bridge: **N/A**
Channel width ratio (channel width upstream / channel width under the bridge: **N/A**

Overbank flow: ☒ yes ☐ no

Percent of flow in main channel of the approach section:
☐ >90% ☒ 75%-90% ☐ 50%-75% ☐ 25%-50% ☐ <25%

Average bed material size (D_{50}):
@ approach section **0.125 ft (field estimate)** ☐ sample taken from sieve analysis
@ bridge **0.125 ft (field estimate)** ☐ sample taken from sieve analysis

Contraction scour susceptibility rating: ☒ low ☐ medium ☐ high

Comments: **Scour with the proposed structure is unlikely due to the elevation of the substructure and velocities at the structure.**

ABUTMENT SUSCEPTIBILITY

Which abutment is worse? ☐ Left ☐ right

Observed scour depth: Remaining embedment in river bed:

Abutment shape: ☐ vertical ☐ vertical with wingwalls ☐ spillthrough

Abutment location: ☐ in channel ☐ at bank ☐ set back

Abutment foundation: ☐ unknown ☐ spread footing ☐ pile bent
☐ friction piles ☐ EB piles ☐ set in rock

Pile type: ☐ metal ☐ concrete ☐ metal ☐ stone

Pile length: ______ m (ft)

Abutment material; ☐ timber ☐ concrete ☐ metal ☐ stone

Angle of inclination: (degrees)

Primary bed material: ☐ sand ☐ gravel ☐ boulders ☐ manmade
☐ silt/clay ☐ cobble ☐ bedrock

Are borings available? ☐ yes ☐ no

Abutment protection

Type: ☐ modified ☐ intermediate ☐ standard ☐ slope
☐ concrete ☐ other ☐ absent ☐ none

Permanent or Temporary: ☐ N/A ☐ permanent ☐ temporary

Condition: ☐ good ☐ weathered ☐ slumped ☐ missing
☐ fair ☐ poor ☐ N/A

Abutment exposure due to scour:

☐ none ☐ no exposure ☐ footing exposed ☐ piles exposed
☐ undermining ☐ settlement ☐ failed

Abutment susceptibility rating: ☐ low ☐ medium ☐ high

Comments: **No existing abutments**

PIER SUSCEPTIBILITY

Worst pier number: **No Existing Piers**
Observed scour depth: Remaining embedment in river bed:

Angle of attack flood flow: (degrees)

Pier foundation: ☐ unknown ☐ spread footing ☐ pile bent
☐ EB piles ☐ set in rock ☐ friction piles ☐ N/A

Pile type: ☐ metal ☐ concrete ☐ timber ☐ N/A

Pile length: _____

Pier material: ☐ stone ☐ wood ☐ metal ☐ N/A

Pier shape: ☐ solid pier with square nose ☐ solid pier with round nose
☐ solid pier with sharp nose ☐ column with square nose ☐ column with round nose
☐ column with sharp nose ☐ cylinders/group of cylinders

Pier width: ______________________ Pier dimensions: ______________________

Cap/Footing dimensions: ____________________________

Pier exposure due to scour: ☐ none ☐ no exposure ☐ footing exposed
☐ piles exposed ☐ undermining ☐ settlement
☐ failed

Pier protection

Type: ☐ modified ☐ intermediate ☐ standard ☐ slope
☐ concrete ☐ other ☐ absent ☐ none
Permanent or Temporary: ☐ N/A ☐ permanent ☐ temporary
Condition: ☐ good ☐ weathered ☐ slumped ☐ missing
☐ fair ☐ poor ☐ N/A

Primary bed material: ☐ sand ☐ gravel ☐ boulders ☐ manmade
☐ silt/clay ☐ cobble ☐ bedrock

Are borings available? ☐ yes ☐ no

Pier susceptibility rating: ☐ low ☐ medium ☐ high

Comments: ______________________________________

B. HYDRAULIC DATA

1) Location

a) Town(s): **Thomaston & Watertown** State Project No.(s): ________

b) Highway: **N/A** Station(s): **N/A**

c) Location Relative to Highway Landmark: **Approximately 0.27 miles south of Route 8 crossing over Branch Brook.**

d) Stream: **Branch Brook**

e) Location Relative to Stream Landmark: **Approximately 1,000 ft upstream of the confluence with Naugatuck River.**

2) Design Flood

a) Hydrologic Procedure Used for Design: **FEMA Flood Insurance Study Flows**

b) Hydrologic Procedure Used by FEMA: **log-Pearson Type III**

c) Drainage Area: **22.6 square miles**

d) ConnDOT Drainage Manual Structure Classification: **Large**

e) Design Storm Frequency: **100-Year, Investigate 500-Year**

f) Required Underclearance at Design Discharge: **2 ft**

g) Design Discharge: **900 cfs**

i. D.O.T. Design: **N/A**

ii. FEMA: **900 cfs**

iii. SCEL: **N/A**

3) Hydraulic Analysis Procedure

a) Model Used and Version No.: **HEC-RAS Version 5.0.7**

b) Flow Regime: **Subcritical**

c) Boundary Conditions (starting water surface at the ends of the river system – i.e. known water surface, normal depth, critical depth, rating curve, etc.):

i. Downstream: **Known WSELs**

ii. Upstream: **N/A**

d) Other Method(s): **N/A**

4) Hydraulic Control (i.e.culvert/bridge, dam (weir), channel construction, tide, known water surface elevation, etc.)

a) Type of Control: **Dam**

b) Location Relative to Proposed Construction: **0.5 miles upstream**

5) Coefficients of Roughness

a) Downstream: Channel **0.035** Overbank **0.065-0.08**

b) At Crossing: Channel **0.035** Enclosed Conduit **N/A**

c) Upstream: Channel **0.035** Overbank **0.065-0.08**

6) Existing Structures

Upstream: **Route 8 bridge**

a) Type: **Two-span bridge on concrete abutments with wingwalls aligned with channel**

b) Gross Waterway Opening: **4,040 square feet (dimensions obtained from FEMA backup data)**

At Site: **None**

a) Type: **N/A**

b) Gross Waterway Opening: **N/A**

c) Effective Waterway Opening: **N/A**

d) Overall Width of Waterway Opening: **N/A**

e) Effective Depth of Waterway Opening: **N/A**

f) Minimum Low Chord Elevation: **N/A**

g) Minimum Roadway Elevation: **N/A**

h) Computed Water Surface Elevation at Approach Section Upstream of Structure at Design Discharge:
324.63-ft (Section 200.65)

i) Underclearance at Design Discharge: **N/A**

j) Mean Velocity of Channel: **4.14 ft/s (Approach Section)**

Downstream: **Dirt road crossing**

a) Type: **Clear-span bridge**

b) Gross Waterway Opening: **Approximately 1,120 square feet (dimensions from FEMA backup data)**

7) Proposed Structures

a) Type: **Prefabricated steel truss superstructure on precast concrete abutments**

b) Gross Waterway Opening: **590± sq ft**

c) Effective Waterway Opening: **208± sq ft**

d) Overall Width of Waterway Opening: **60 ft**

e) Effective Depth of Waterway Opening: **6.5 ft**

f) Minimum Low Chord Elevation: **331.25 ft**

g) Minimum Roadway Elevation: **332 ft (Proposed trail elevation)**

h) Computed Water Surface Elevation at Approach Section Upstream of Structure at Design Discharge:
324.63 ft at Section 200.65

i) Maximum Regulatory Elevation: **325.58 ft (natural conditions + 1-ft) calculated at Approach Section 200.65**

j) Other Controlling Water Surface Elevation (If Below Maximum Regulatory Elev.):
Known FEMA WSELs

k) Difference in Water Surface Elevation (Approach Section) Proposed vs. Existing and Proposed vs. Regulatory @ Design Discharge:
At Section 200.65, the Proposed WSEL is 324.63-ft, equivalent to the Existing WSEL, and approximately 0.05-ft higher than the Natural Conditions (324.58 ft). The Proposed WSEL is 0.95-ft below the Regulatory Elevation (Natural plus 1 ft).

l) Underclearance at Design Discharge with Respect to Structure Low Chord:
6.62-ft

m) Mean Velocity Through Structure: **4.40 ft/s – Bridge Open Velocity**

8) Remarks

a) Navigational Requirements: **N/A**

b) Tidal Conditions: **N/A**

c) Record Floods: **August 1955, Over 500-year storm (FIS Report/CT Drainage Manual/NOAA Data)**

d) Average Daily Flow: **39.7 cfs**
(Q_{AD}(cfs) = $[A\ (sm)]^{0.98} * 1.87$)

e) Average Spring Flow: **78.8 cfs**
(Q_{AS}(cfs) = $[A\ (sm)]^{0.988} * 3.62$)

f) Flood Hazard Zone: **Zone A1**

g) Vertical Datum: **NAVD 1988 (FEMA data in NGVD 1929)**

APPENDIX D – LEVEL II SCOUR RESULTS

- 200-Year Storm Event Scour Data Sheet and Calculations
- 500-Year Storm Event Scour Data Sheet and Calculations

LEVEL II SCOUR RESULTS

- 200-Year Storm Event Scour Data Sheet and Calculations

Companies

100 Constitution Plaza, 10th Floor
Hartford, Connecticut 06103

PROJECT : **Naugatuck River Greenway**

BL PROJECT NO.: 1800579
PREPARED BY: Brandon Rojas Date: 11/21/2019
CHECKED BY: David Cicia Date:

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HEC-RAS Plan : Proposed Conditions Scour Flow
Approach Section = 200.65
Abutment Projection Left = 51
Abutment Projection Right = 111
Θ_L = 90
Θ_R = 90

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200-YEAR STORM

LT			RT	
Edge Flow =	52.65	EC-RAS 200.65	Edge Flow =	124.74
Edge Active Flow =	50.7	EC-RAS 200.65	Edge Active Flow =	115.51
L =	-1.65		L =	13.74
L' =	0.3		L' =	4.51
Obstructed Flow =	0.98	Below	Obstructed Flow =	14.20
Obstructed Area =	0.52	Below	Obstructed Area =	11.62

Left Sta	Right Sta	Flow	Area	Flow/Width
50.70	63.37	41.44	21.77	3.27
63.37	67.46	78.79	24.15	19.26
67.46	71.55	106.69	27.83	26.09
71.55	75.65	211.40	30.36	51.56
75.65	79.74	257.53	32.48	62.97
79.74	83.83	254.49	32.36	62.22
83.83	87.92	155.21	29.54	37.95
87.92	92.01	108.45	28.01	26.52
92.01	96.11	99.59	26.61	24.29
96.11	100.20	86.85	24.65	21.23
100.20	104.29	66.81	21.11	16.33
104.29	115.51	31.01	20.73	2.76
115.51	126.74	1.74	3.29	0.15

OBSTRUCTED FLOW AND AREA

Abut Project LT =	51
n Width (63.37-50.70) =	12.67
e Width (51.00-50.70) =	0.30
% to Include =	2.4%
Total Flow =	0.98
Total Area =	0.52
Abut Project RT =	111
Width (115.51-104.29) =	11.22
Width (115.51-111.00) =	4.51
% to Include =	40.2%
Total Flow =	14.20
Total Area =	11.62

Note:
Shaded cells are within the active fl

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SCOUR ANALYSIS

Pedestrian Bridge over Branch Brook

Thomaston & Watertown, CT

STEP 1: SCOUR ANALYSIS VARIABLES

		200-Year
A	Discharge Considered in Analysis	Q = 1,500 cfs

B Conditions at Approach Section APPROACH SECTION #200.65

Hydraulic Variables	LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK	REFERENCE
Discharge [cfs]	41.4	1425.8	32.8	HEC-RAS 1.608
Area of Flow [sf]	21.8	277.1	24.0	HEC-RAS 1.608
Top Width of Flow [ft]	10.7	40.9	20.5	HEC-RAS 1.608
Bottom Width [ft]	11.8	41.8	21.5	HEC-RAS 1.608
Energy Slope [ft/ft]	---	0.0031	---	HEC-RAS 1.608
Manning's "n"	0.065	0.056	0.065	HEC-RAS 1.608

Bed Material	D_{50} [ft]	D_m [ft]
LEFT OVERBANK	0.125	0.1563
MAIN CHANNEL	0.125	0.1563
Fall Vel. (Fig.6.8,HEC18)	2.00	
RIGHT OVERBANK	0.125	0.1563
Specific Gravity of Bed Material	2.65	

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SCOUR ANALYSIS

Pedestrian Bridge over Branch Brook

Thomaston & Watertown, CT

C Conditions at the Bridge — BRIDGE FACE SECTION # 200.6

	LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK	
Contracted Flow [cfs]	71.0	1384.9	44.1	HEC-RAS 200.6
Area of Flow [sf]	28.6	235.9	21.5	HEC-RAS 200.6
Flow Width [ft]	8.4	35.9	8.8	HEC-RAS 200.6
Angle of Flow [deg]	90	-	90	
Obstructed Length [ft]	0.3	-	4.5	See Data Sheet
Obstructed Flow [cfs]	4.3	-	80.1	See Data Sheet
Obstructed Area [sf]	3.5	-	39.3	See Data Sheet
Vel. at Abutment [fps]	2.49	-	2.10	HEC-RAS 200.58 U
Depth at Abutment [ft]	0.00	-	0.25	HEC-RAS 200.58 U
Bridge Abutment Type:	Vertical Abutment with Wing Walls		0.82	

STEP 2 - DETERMINATION OF CONTRACTION SCOUR

A CRITICAL VELOCITY — APPROACH SECTION #200.65

Vc = Ku*[(y1)^1/6]*[(D50)^1/3]

	LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK
Ku - Combined Constant = 11.17 for English units			
Y1 - Avg Depth Apprch Sec	2.03	6.77	1.17
V1 - Avg Vel Approach Sec	1.90	5.15	1.36
Vc - Critical Velocity	6.28	7.68	5.74
SCOUR EQUATION TYPE	CLEAR WATER	CLEAR WATER	CLEAR WATER

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SCOUR ANALYSIS

Pedestrian Bridge over Branch Brook

Thomaston & Watertown, CT

B LIVE BED CONTRACTION SCOUR

Y2/Y1=((Q2/Q1)^6/7)*(W1/W2)^k1 Ys = Y2 - YO

	LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK	
Q1 - Flow up trnsprtg sed	41.4	1425.8	32.8	
Q2 - Flow bdg trnsprt sed	71.0	1384.9	44.1	
W1 - Bttm width trnsp sed	11.8	41.8	21.5	
W2 - Bttm width trnsp sed	53.0	60.0	228.4	W2 = Clear Span
Y1 - Avg depth up trnsprt	2.0	6.8	1.2	
Y2 - Avg depth bdg trnsprt	#DIV/0!	5.3	#DIV/0!	
Y0 - Exs dpth befor scour	xxx	8.1	xxx	HEC-RAS 200.6
Ys - Depth Live Bed Cntrc	#DIV/0!	0.0	#DIV/0!	

V*/w	Bed Material Transport	k1
< 0.5	Mostly Contact	0.59
0.5 - 2.0	Some Suspended	0.64
> 2.0	Mostly Suspended	0.69

	LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK
V*	0.45	0.82	0.34
w	0.00	2.00	0.00
k1	#DIV/0!	0.59	#DIV/0!

g - Gravity constant	[32.2 fps^2]
Sf - Slope of Energy Grade	0.0031
V* = (g*Y1*Sf)^0.5 - Shear Velocity	[fps]
w - Fall Velocity (see Fig.5.8, HEC18)	[fps]

C CLEAR WATER CONTRACTION SCOUR

Y2 = [0.0077*Q^2/(Dm^2/3*W^2)]^3/7 Ys = Y2 - Y0

	LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK	
Q - Flow bdg trnsprtg sed	71.0	1384.9	44.1	
W - Bottm width trnsp sed	53.0	46.5	228.4	W2 = Clear Span
Dm - Effectv mean diametr	0.1563	0.1563	0.1563	
Y2 - Avg equilbrium depth	0.3	3.9	0.1	
Y0 - Avg existg depth @ W	3	6.6	2	HEC-RAS 200.6
Ys - Depth Clear Wat Cntr	0	0.00	0	

D **CONTRACTION SCOUR** LEFT OVERBANK MAIN CHANNEL RIGHT OVERBANK

Design Contraction Scour is the LESSER of
the Live Bed or Clear Water scour estimates:

	LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK
Ys - Contraction Scour	**#DIV/0!**	**0.0**	**#DIV/0!**

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SCOUR ANALYSIS

Pedestrian Bridge over Branch Brook

Thomaston & Watertown, CT

STEP 3 - DETERMINATION OF SCOUR AT ABUTMENTS

A FROEHLICH'S EQUATION (As revised per ConnDOT Drainage Manual)

Ys/Ya = [2.27*K1*K2*(L'/Ya)^0.43*Fr^0.61]+0.05

K1 - Abutment Shape Coefficient	
K2 - Angle of Flow Coefficient - Defined by "Theta"	
L' - Length of Active Flow obstructed by embankment	[ft]
Ae - Approach sect flow area obstructed by the embankment	[sf]
Qe - Approach sect flow obstructed by the embankment	[cfs]
Ya - Average flow depth on the floodplain	[ft]
Ve = Qe/Ae	[fps]
Fr = Ve/(gYe)^0.5 Froude Number	
L - Length of embankment projected normal to the flow	[ft]
Ys - Depth of scour	[ft]

1 Abutment Shape Coefficient

Bridge Abutment Type: Vertical Abutment with Wing Walls

DESCRIPTION	K1
Vertical Abutment without Wing Walls	1.00
Vertical Abutment with Wing Walls	0.82
Spill Through Abutment	0.55

K1 = 0.82 PICK BRIDGE TYPE

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SCOUR ANALYSIS

Pedestrian Bridge over Branch Brook

Thomaston & Watertown, CT

2 ABUTMENT SCOUR

	LEFT OVERBANK	RIGHT OVERBANK
Theta	90	90
K2 = (Theta/90)^0.13	1	1
L'	0.3	4.5
Ae	3	23
Qe	4	46
Ya	0.8	1.2
Ve	1.23	2.03
Fr	0.251	0.327
L	4.6	18.9
Ys	0.4	2.0

B HIRE EQUATION - Live-Bed Abutment Scour

Based on Equation from:
Richardson, E.V., Simons, D.B., Julien, P. "Highways in the River Environment", FHWA-HI-90-016, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C.

Ys/Y1 = 4*Fr^0.33*(K1/0.55)*K2 Applicable if: L/Y1 > 25

L - Length of Abutment Projection	[ft]
A1 - Flow Area Obstructed by the Embankment	[sf]
Q1 - Flow Obstructed by the Embankment	[cfs]
Y1 - Flow Depth at the Abutment	[ft]
V1 - Velocity of Flow at Abutment	[fps]
Fr1 = V1/(gY1)^0.5 Froude Number	
Ys - Depth of scour	[ft]

		LEFT OVERBANK	RIGHT OVERBANK
L/Y1		#DIV/0!	18
Y1	[ft]	0.0	0.3
V1	[fps]	2.49	2.10
Fr = V1/(g*Y1)^0.5		#DIV/0!	0.740
Ys/Y1		#DIV/0!	3.622
Ys		#DIV/0!	Not Applicable

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BL PROJECT NO.: 1800579
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CHECKED BY: David Cicia Date:

SCOUR ANALYSIS
Pedestrian Bridge over Branch Brook
Thomaston & Watertown, CT

STEP 4 - NCHRP ABUTMENT SCOUR CALCULATION

L - Length of embankment projected normal to the flow	[ft]	HEC-RAS 200.58 U
B_f - Floodplain Width	[ft]	HEC-RAS 200.58 U

	LEFT OVERBANK	RIGHT OVERBANK	
L	12.2	10.2	Abutments set
B_f	12.2	10.2	at Main Channel
$(L/B_f)*100\%$	100	100	
SCOUR CALCULATION METHOD	LIVE-BED SCOUR	LIVE-BED SCOUR	

$y_c = y_1*(q_{2c}/q_1)$^6/7

y_c - Flow depth including live-bed contraction scour	[ft]
y_1 - Upstream flow depth	[ft]
q_{2c} - Unit discharge in the constricted opening	[ft^2/s]
q_1 - Upstream unit discharge	[ft^2/s]

$$q_{2c} = \frac{\text{total bridge opening discharge}}{\text{width of the bridge opening}}$$

y_1	6.77	[ft]	HEC-RAS 200.65
q_{2c}	25.0	[ft^2/s]	
q_1	34.8	[ft^2/s]	HEC-RAS 200.65
y_c	5.1	[ft]	

$y_{max} = x_a \cdot y_c$

y_{max} - Maximum flow depth resulting from abutment scour	[ft]
x_a - Amplification factor for live-bed conditions	[ft]

q_{2c}/q_1	0.72		
x_a	2.0		HEC-18, Fig 8.10
y_{max}	10.19	[ft]	

$y_s = y_{max} - y_o$

y_s - Abutment scour depth	[ft]	
y_o - Flow depth prior to scour	[ft]	HEC-RAS 200.6

y_s	2.07	[ft]

LEVEL II SCOUR RESULTS

- 500-Year Storm Event Scour Data Sheet and Calculations

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HEC-RAS Plan : Proposed Conditions Scour Flow
Approach Section = 200.65
Abutment Projection Left = 51
Abutment Projection Right = 111
Θ_L = 90
Θ_R = 90

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500-YEAR STORM

LT			RT	
Edge Flow =	46.38	HEC-RAS 1.608	Edge Flow =	129.93
Edge Active Flow =	50.7	HEC-RAS 1.608	Edge Active Flow =	115.51
L =	4.62		L =	18.93
L' =	0.3		L' =	4.51
Obstructed Flow =	4.30	Below	Obstructed Flow =	80.08
Obstructed Area =	3.48	Below	Obstructed Area =	39.26

Left Sta	Right Sta	Flow	Area	Flow/Width
38.02	50.70	1.90	2.48	0.15
50.70	63.37	101.26	42.33	7.99
63.37	67.46	120.79	30.96	29.53
67.46	71.55	155.74	34.63	38.08
71.55	75.65	299.91	37.16	73.15
75.65	79.74	358.46	39.28	87.64
79.74	83.83	354.59	39.16	86.70
83.83	87.92	221.89	36.34	54.25
87.92	92.01	157.97	34.81	38.62
92.01	96.11	147.55	33.41	35.99
96.11	100.20	132.17	31.45	32.32
100.20	104.29	107.90	27.91	26.38
104.29	115.51	100.00	39.39	8.91
115.51	126.74	38.26	21.44	3.41
126.74	137.96	1.62	1.99	0.14

OBSTRUCTED FLOW AND AREA

Abut Project LT =	51
n Width (63.37-50.70) =	12.67
e Width (51.00-50.70) =	0.30
% to Include =	2.4%
Total Flow =	4.30
Total Area =	3.48
Abut Project RT =	111
Width (115.51-104.29) =	11.22
Width (115.51-111.00) =	4.51
% to Include =	40.2%
Total Flow =	80.08
Total Area =	39.26

Note:
Shaded cells are within the active fl

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SCOUR ANALYSIS

Pedestrian Bridge over Branch Brook

Thomaston & Watertown, CT

STEP 1: SCOUR ANALYSIS VARIABLES

A Discharge Considered in Analysis — 500-Year, Q = 2,300 cfs

B Conditions at Approach Section — APPROACH SECTION # 200.65

Hydraulic Variables	LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK	REFERENCE
Discharge [cfs]	103.2	2057.0	139.9	HEC-RAS 200.65
Area of Flow [sf]	44.8	345.1	62.8	HEC-RAS 200.65
Top Width of Flow [ft]	17.0	40.9	25.6	HEC-RAS 200.65
Bottom Width [ft]	18.3	41.8	27.0	HEC-RAS 200.65
Energy Slope [ft/ft]	---	0.0031	---	HEC-RAS 200.65
Manning's "n"	0.065	0.056	0.065	HEC-RAS 200.65

Bed Material	D_{50} [ft]	Dm [ft]
LEFT OVERBANK	0.125	0.1563
MAIN CHANNEL	0.125	0.1563
Fall Vel. (Fig.6.8,HEC18)	2.00	
RIGHT OVERBANK	0.125	0.1563
Specific Gravity of Bed Material	2.65	

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SCOUR ANALYSIS

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		LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK	
C	Conditions at the Bridge		BRIDGE FACE SECTION # 1.598		
	Contracted Flow [cfs]	110.1	2086.4	103.5	HEC-RAS 200.6
	Area of Flow [sf]	44.5	290.2	36.0	HEC-RAS 200.6
	Flow Width [ft]	15.4	35.9	11.2	HEC-RAS 200.6
	Angle of Flow [deg]	90	-	90	
	Obstructed Length [ft]	0.3	-	4.5	See Data Sheet
	Obstructed Flow [cfs]	4.3	-	80.1	See Data Sheet
	Obstructed Area [sf]	3.5	-	39.3	See Data Sheet
	Vel. at Abutment [fps]	2.53	-	2.80	HEC-RAS 200.58 U
	Depth at Abutment [ft]	0.00	-	1.74	HEC-RAS 200.58 U
	Bridge Abutment Type:	Vertical Abutment with Wing Walls		0.82	

STEP 2 - DETERMINATION OF CONTRACTION SCOUR

		LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK
A	CRITICAL VELOCITY		APPROACH SECTION # 200.65	
	Vc = Ku*[(y1)^1/6]*[(D50)^1/3]			
	Ku - Combined Constant = 11.17 for English units			
	Y1 - Avg Depth Apprch Sec	2.64	8.43	2.45
	V1 - Avg Vel Approach Sec	2.30	5.96	2.23
	Vc - Critical Velocity	6.56	7.97	6.48
	SCOUR EQUATION TYPE	CLEAR WATER	CLEAR WATER	CLEAR WATER

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SCOUR ANALYSIS

Pedestrian Bridge over Branch Brook

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B LIVE BED CONTRACTION SCOUR

Y2/Y1=((Q2/Q1)^6/7)*(W1/W2)^k1 Ys = Y2 - YO

	LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK	
Q1 - Flow up trnsprtg sed	103.2	2057.0	139.9	
Q2 - Flow bdg trnsprt sed	110.1	2086.4	103.5	
W1 - Bttm width trnsp sed	18.3	41.8	27.0	
W2 - Bttm width trnsp sed	53.0	60.0	228.4	W2 = Clear Span
Y1 - Avg depth up trnsprt	2.6	8.4	2.5	
Y2 - Avg depth bdg trnsprt	#DIV/0!	6.9	#DIV/0!	
Y0 - Exs dpth befor scour	xxx	9.5	xxx	HEC-RAS 200.6
Ys - Depth Live Bed Cntrc	#DIV/0!	0.0	#DIV/0!	

V*/w	Bed Material Transport	k1
< 0.5	Mostly Contact	0.59
0.5 - 2.0	Some Suspended	0.64
> 2.0	Mostly Suspended	0.69

	LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK
V*	0.51	0.91	0.49
w	0.00	2.00	0.00
k1	#DIV/0!	0.59	#DIV/0!

g - Gravity constant	[32.2 fps^2]
Sf - Slope of Energy Grade	0.0031
V* = (g*Y1*Sf)^0.5 - Shear Velocity	[fps]
w - Fall Velocity (see Fig.5.8, HEC18)	[fps]

C CLEAR WATER CONTRACTION SCOUR

Y2 = [0.0077*Q^2/(Dm^2/3*W^2)]^3/7 Ys = Y2 - Y0

	LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK	
Q - Flow bdg trnsprtg sed	110.1	2086.4	103.5	
W - Bottm width trnsp sed	53.0	46.5	228.4	W2 = Clear Span
Dm - Effectv mean diametr	0.1563	0.1563	0.1563	
Y2 - Avg equilbrium depth	0.4	5.5	0.1	
Y0 - Avg existg depth @ W	3	8.0	3	HEC-RAS 200.6
Ys - Depth Clear Wat Cntr	0	0.00	0	

D **CONTRACTION SCOUR** LEFT OVERBANK MAIN CHANNEL RIGHT OVERBANK

Design Contraction Scour is the LESSER of the Live Bed or Clear Water scour estimates:

	LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK
Ys - Contraction Scour	**#DIV/0!**	**0.0**	**#DIV/0!**

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STEP 3 - DETERMINATION OF SCOUR AT ABUTMENTS

A FROEHLICH'S EQUATION (As revised per ConnDOT Drainage Manual)

Ys/Ya = [2.27*K1*K2*(L'/Ya)^0.43*Fr^0.61]+0.05

K1 - Abutment Shape Coefficient		
K2 - Angle of Flow Coefficient - Defined by "Theta"		
L' - Length of Active Flow obstructed by embankment	[ft]	
Ae - Approach sect flow area obstructed by the embankment	[sf]	
Qe - Approach sect flow obstructed by the embankment	[cfs]	
Ya - Average flow depth on the floodplain	[ft]	
Ve = Qe/Ae	[fps]	
Fr = Ve/(gYe)^0.5 Froude Number		
L - Length of embankment projected normal to the flow	[ft]	
Ys - Depth of scour	[ft]	

1 Abutment Shape Coefficient

Bridge Abutment Type: Vertical Abutment with Wing Walls

DESCRIPTION	K1
Vertical Abutment without Wing Walls	1.00
Vertical Abutment with Wing Walls	0.82
Spill Through Abutment	0.55

K1 = 0.82 PICK BRIDGE TYPE

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2 ABUTMENT SCOUR

	LEFT OVERBANK	RIGHT OVERBANK
Theta	90	90
K2 = (Theta/90)^0.13	1	1
L'	0.3	4.5
Ae	3	38
Qe	4	107
Ya	0.8	2.0
Ve	1.23	2.82
Fr	0.251	0.352
L	4.6	18.9
Ys	0.4	2.9

B HIRE EQUATION - Live-Bed Abutment Scour

Based on Equation from:
Richardson, E.V., Simons, D.B., Julien, P. "Highways in the River Environment", FHWA-HI-90-016, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C.

Ys/Y1 = 4*Fr^0.33*(K1/0.55)*K2 Applicable if: L/Y1 > 25

L - Length of Abutment Projection	[ft]
A1 - Flow Area Obstructed by the Embankment	[sf]
Q1 - Flow Obstructed by the Embankment	[cfs]
Y1 - Flow Depth at the Abutment	[ft]
V1 - Velocity of Flow at Abutment	[fps]
Fr1 = V1/(gY1)^0.5 Froude Number	
Ys - Depth of scour	[ft]

		LEFT OVERBANK	RIGHT OVERBANK
L/Y1		#DIV/0!	3
Y1	[ft]	0.0	1.7
V1	[fps]	2.53	2.80
Fr = V1/(g*Y1)^0.5		#DIV/0!	0.374
Ys/Y1		#DIV/0!	2.892
Ys		#DIV/0!	Not Applicable

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SCOUR ANALYSIS

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STEP 4 - NCHRP ABUTMENT SCOUR CALCULATION

L - Length of embankment projected normal to the flow	[ft]	HEC-RAS 200.58 U
B_f - Floodplain Width	[ft]	HEC-RAS 200.58 U

	LEFT OVERBANK	RIGHT OVERBANK	
L	12.2	10.2	Abutments set
B_f	12.2	10.2	at Main Channel
$(L/B_f)*100\%$	100	100	
SCOUR CALCULATION METHOD	LIVE-BED SCOUR	LIVE-BED SCOUR	

$y_c = y_1*(q_{2c}/q_1)$^6/7

y_c - Flow depth including live-bed contraction scour	[ft]
y_1 - Upstream flow depth	[ft]
q_{2c} - Unit discharge in the constricted opening	[ft^2/s]
q_1 - Upstream unit discharge	[ft^2/s]

$$q_{2c} = \frac{\text{total bridge opening discharge}}{\text{width of the bridge opening}}$$

y_1	8.43	[ft]	HEC-RAS 200.65
q_{2c}	38.3	[ft^2/s]	
q_1	50.3	[ft^2/s]	HEC-RAS 200.65
y_c	6.7	[ft]	

$y_{max} = x_a \cdot y_c$

y_{max} - Maximum flow depth resulting from abutment scour	[ft]
x_a - Amplification factor for live-bed conditions	[ft]

q_{2c}/q_1	0.76		
x_a	2.0		HEC-18, Fig 8.10
y_{max}	13.37	[ft]	

$y_s = y_{max} - y_o$

y_s - Abutment scour depth	[ft]	
y_o - Flow depth prior to scour	[ft]	HEC-RAS 200.6

y_s	3.83	[ft]